EDN®

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

PRODUCT SHOWCASE

TINY SPDT SWITCHES
ABSORPTIVE... REFLECTIVE

dc to 4.6 GHz *from* $32⁹⁵ (10-24)

Tough enough to pass stringent MIL-STD-883 vibration, shock, thermal shock, fine and gross leak tests...useable to 6GHz...smaller than most RF switches...Mini-Circuits' hermetically-sealed (reflective) KSW-2-46 and (absorptive) KSWA-2-46 offer a new, unexplored horizon of applications. Unlike pin diode switches that become ineffective below 1MHz, these GaAs switches can operate down to dc with control voltage as low as -5V, at a blinding 2ns switching speed.

Despite its extremely tiny size, only 0.185 by 0.185 by 0.06 in., these switches provide 50dB isolation (considerably higher than many larger units) and insertion loss of only 1dB. The absorptive model KSWA-2-46 exhibits a typical VSWR of 1.5 in its "OFF" state over the entire frequency range. These surface-mount units can be soldered to pc boards using conventional assembly techniques. The KSW-2-46, priced at only $32.95, and the KSWA-2-46, at $48.95, are the latest examples of components from Mini-Circuits with unbeatable price/performance.

Connector versions, packaged in a 1.25 x 1.25 x 0.75 in. metal case, contain five SMA connectors, including one at each control port to maintain 3ns switching speed.
Switch fast... to Mini-Circuits' GaAs switches.

SPECIFICATIONS

Pin Model Connector Version	**KSW-2-46** **ZFSW-2-46**		**KSWA-2-46** **ZFSWA-2-46**	
FREQ. RANGE	dc-4.6 GHz		dc-4.6 GHz	
INSERT. LOSS (db)	typ	max	typ	max
dc-200MHz	0.9	1.1	0.8	1.1
200-1000MHz	1.0	1.3	0.9	1.3
1-4.6GHz	1.3	1.7	1.5	2.6
ISOLATION (dB)	typ	min	typ	min
dc-200MHz	60	50	60	50
200-1000MHz	45	40	50	40
1-4.6GHz	30	23	30	25
VSWR (typ) ON	1.3:1		1.3	
OFF	—		1.4	
SW. SPEED (nsec) rise or fall time	2(typ)		3(typ)	
MAX RF INPUT (bBm) up to 500MHz	+17		+17	
above 500MHz	+27		+27	
CONTROL VOLT.	-8V on, OV off		-8V on, OV off	
OPER/STOR TEMP.	-55° to +125°C		-55° to +125°C	
PRICE (10-24)	**$32.95** $69.95		**$48.95** $79.95	

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CIRCLE NO 15   C 117 REV. G

On the cover: Part 1 of EDN's Product Showcase No. 30 describes offerings from manufacturers of hardware and interconnect devices, integrated circuits, power sources, and software. Staff-written analyses introduce each product category and focus on elastomeric connectors (pg 74), audio DACs (pg 112), rechargeable portable batteries (pg 180), and Unix standards (pg 226). (Cover photography by Kevin Bryan; art direction by Pat Crowell and Ken Racicot)

BPA ABP

EDN's semiannual Product Showcase highlights the cream of the crop in four technology areas: hardware and inter connect devices (pg 83); ICs (pg 127); power sources (pg 193); and software (pg 235).

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CIRCLE NO 16

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EDITORIAL 45

A clearing house that matches donors and recipients of leftover equipment and excess inventory benefits colleges and universities. But, it needs your company's participation.

PROFESSIONAL ISSUES 303

Who owns your ideas? Part 1 of this 2-part article discusses employment agreements and trade secrets. —*Jay Fraser, Associate Editor*

DEPARTMENTS
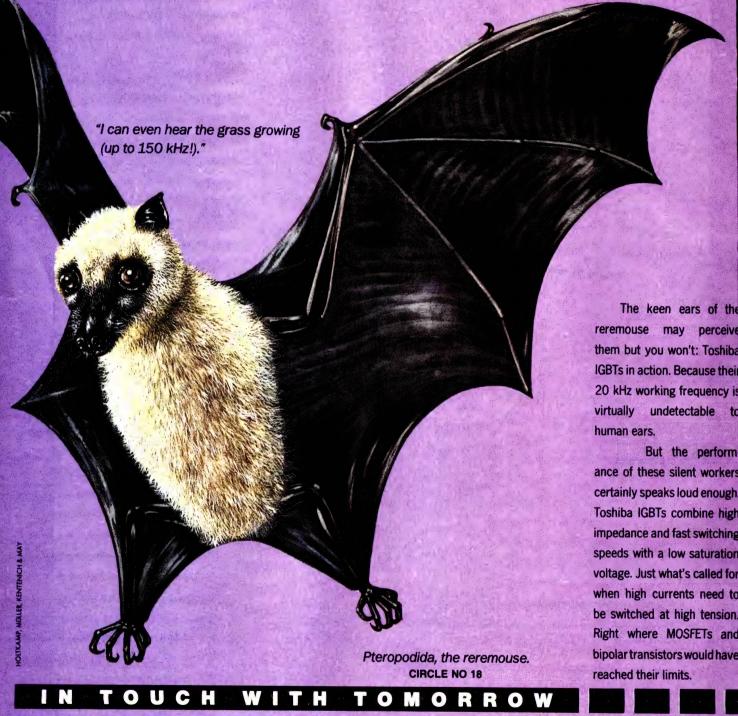
A product-oriented design aid

To save you time in your efforts to keep current, EDN's editors have surveyed the new-product offerings from thousands of companies, screening and selecting only the most significant of those offerings introduced in the last six months. We present our findings—the best of the best—in a format devised to make your product selection as easy as possible. You can keep this Product Showcase as a reference until the next one that covers these four key product areas appears in July.

SIEMENS

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A19100-N63-Z6-V1-7600

FDDI

The future of FDDI is here. The race to win the new LAN market took off with the recent agreement on the FDDI standard. And already, one thing is clear: Siemens is at the head of the pack.

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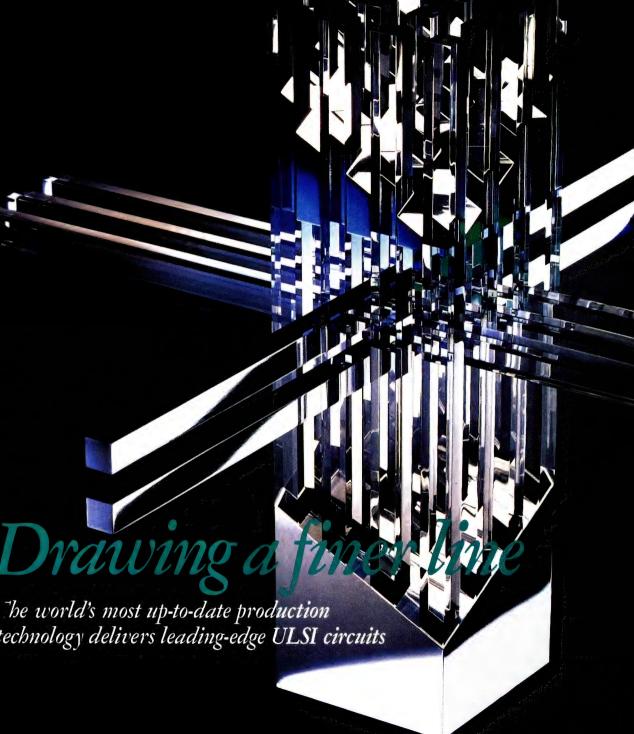
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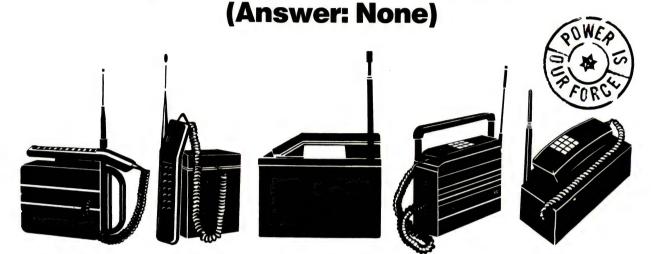
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15

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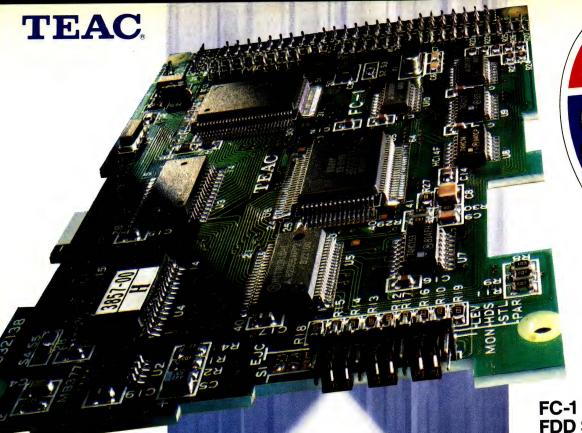
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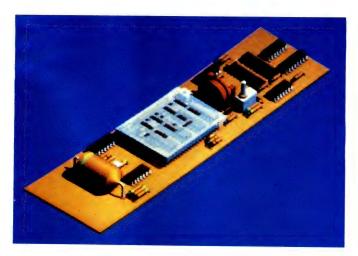
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NEWS BREAKS

ALLIANCES EXTEND SIMULATION FRAMEWORK

A simulation framework interconnects and synchronizes a range of different simulators. Unfortunately, connecting simulators is not a plug-and-play operation—if the vendors don't supply an interface, your CAD group has to write one. Silicon Compiler Systems Corp's newly created Simulation Division (San Jose, CA, (408) 371-2900) has announced interfaces between three different simulators and its simulation framework. One interface is to the Zycad (Menlo Park, CA, (415) 688-7400) Mach hardware accelerator; it costs $40,000 and will be available in the fourth quarter of 1990. Another simulator lets you run Electrical Engineering Software's (Santa Clara, CA, (408) 296-8151) Precise Spice derivative within SCS's framework; it costs $1000 and will be available next month. SCS is also writing an interface for Analogy Inc's (Beaverton, OR, (503) 626-9700) Saber analog simulator; it will be available in the second quarter of 1990.

SCS will also offer a VHDL (VHSIC hardware-description language) simulation capability through an alliance with Cad Language Systems Inc (Rockville, MD, (301) 424-9445). The VHDL capability will be available in the second quarter of 1990 as a $30,000 option to Lsim, SCS's simulator, or for $42,000 as a stand-alone simulator. Alternatively, you can execute models directly in SCS's M hardware-description language; Logic Automation (Beaverton, OR, (503) 690-6900) has written a version of its SmartModels standard-parts libraries in that language. The library costs $6000.—Michael C Markowitz

CSICs SLASH DESIGN CYCLES FOR CUSTOMIZABLE CHIPS

You can now "cut and paste" controller subsystems from 31 versions of the 68HC05 family of 8-bit microcontrollers to create a new chip that uniquely suits your particular application in as little as six months. Motorola (Austin, TX, (512) 891-3260) calls this customer-specific IC technology CSIC (pronounced "seasick"). By using standard, proven functional subsystems, CSIC designs maximize circuit reliability and minimize or eliminate engineering and design charges. Controller subsystems include watchdog and general-purpose timers, serial and parallel ports, A/D converters, EEPROMs, EPROMs, pulse-width-modulator channels, and flat-panel display drivers. Although this technology is cost effective only for high-volume orders, Motorola has developed a database that mates similar CSIC requests from multiple, small-volume customers. Motorola will then develop the chip when the combined orders reach significant OEM volumes.—J D Mosley

FLEXIBLE CIRCUITS SURVIVE UNDER-THE-HOOD TEMPERATURES

A stumbling block to the use of flexible circuits under automobile hoods has been the harsh environment these circuits must withstand. Operating temperatures can reach 150°C, and the circuits can be splashed with a wide range of fuels and solvents. Rogers Corp (Chandler, AZ, (602) 963-4584) has developed a flexible-circuit material made from two different polyimide films laminated with a phenolic butral adhesive on treated copper foil. The laminate appears to withstand the two prevalent failure modes of an automotive environment: the loss of adhesion between the etched copper trace and the substrate dielectric, and the thermally or chemically induced deterioration of the insulation's dielectric properties.—Margery Conner

NEWS BREAKS

COMPLETE MACHINE-VISION SYSTEM COSTS LESS THAN $5000

If you're looking for a bargain in an industrial vision system, take a look at the $4995 LCVS-5 from Industrial Perception Systems (Pittsburgh, PA, (412) 821-6900). The system includes an 80286-based computer with EGA graphics, an RGB color monitor, and a low-light, solid-state, 512×482-pixel camera. The computer comes with a vision interface board, a 20M-byte hard-disk drive, and a 4-camera multiplexer input. The system's software includes vision algorithms and Microsoft's QuickBasic. The manufacturer offers a 1-year guarantee on all components.—J D Mosley

MILITARY PROGRAMMABLE GATE ARRAYS ARE NONVOLATILE

Field-programmable gate arrays (FPGAs) from Actel (Sunnyvale, CA, (408) 739-1010) meet MIL-I-45208A, and the vendor expects to upgrade the parts to MIL-Q-9858A and MIL-M-3851H in the first quarter of 1990. The 1200 and 2000 equivalent-gate CMOS FPGAs use antifuses for the programmable element. Preliminary tests indicate a radiation tolerance of greater than 1.5 Mrad (Si) steady-state total dose. The high radiation tolerance is especially important for military and satellite applications. The Act 1 family of FPGAs also offers security from reverse engineering. The small antifuse elements cannot be identified optically or with a scanning electron microscope, thus making reverse engineering almost impossible.

Prices for MIL-STD-883C level B parts in 84-pin PGA packages start at $223.74 (100); prices for data-sheet military parts without full MIL-STD-883C testing start at $120.87 (100).—Doug Conner

GaAs GATE-ARRAY FAMILY ACQUIRES A SECOND PARENT

The Fury gate-array family from Vitesse Semiconductor (Camarillo, CA, (805) 388-3700) now has an alternate source. Fujitsu Microelectronics (San Jose, CA, (408) 922-9000) has entered an agreement with Vitesse to produce pin-compatible GaAs devices using Fujitsu's MESFET process. Even though they are manufactured using different processes, components from the two manufacturers will be completely interchangeable. The gate arrays have sizes of 3000 to 30,000 gates, and mixed logic/static RAM arrays. The two companies will also be jointly developing additional GaAs products.

The 30,000-gate Fury-family gate array has ECL-equivalent speeds that require only about a third of the power of ECL and has a typical power dissipation of 8 to 12W. Its D flip-flop toggle rates exceed 1 GHz, and the typical gate delay is 177 psec. Available I/O interface levels include TTL, ECL (10K, 10 KH, and 100K), and GaAs. You can also mix these levels around a chip's inputs and outputs. Vitesse prices the part at $1500 (1000).—Richard A Quinnell and Margery Conner

THREE REPORTS TELL YOU WHERE TO BUY R&D TECHNOLOGY

Estimating that 99% of new developments will come from outside of your company, Technical Insights Inc (Fort Lee, NJ, (201) 568-4744) has published three guides that can help you use other people's technology. The $295 report *Japanese Technical Information Sources: How to Profit From the Japanese R&D Explosion* lists the names and addresses of more than 170 contacts that can help you make agreements with public and private Japanese institutions to use their technology. It also includes a list of 31 translation organiza-

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256K Cache RAM

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CY7C604 CMMU
Cache/Memory Management Unit

23

NEWS BREAKS

tions that specialize in technical documents and 47 firms that report on new technology developments. *Industry/University Partnering: How Industry Can Find/Use Academic Research Labs* guides you to contacts in US and Canadian universities that are interested in joint development projects. It costs $195. The $195 *Profiting from Other People's Technology: A Guide to Technology Transfer Opportunities* explains the specific arrangements sought by US and overseas universities, private companies, and government labs. The guides cover such technologies as adhesives, material science, and automation.—Steven H Leibson

GATE ARRAY SIMPLIFIES TIMING ANALYSIS

A field-programmable gate-array family from Plus Logic (Santa Clara, CA, (408) 727-3864) lets you design your circuits without having to recheck their timing once they've been mapped into the array. The family's first member, the FPGA2020, provides you with the equivalent of 1500 to 2000 gates.

The family's architecture divides the active circuit elements into blocks joined with an active interconnect matrix. You design your circuit using logic elements from Plus Logic's CAD design library. Each of these logic elements is completely specified, including fan-out and propagation delays. Once you design your circuit, the CAD system maps the circuit into the array's blocks. On-chip propagation delays between blocks are compensated for in the interconnect matrix, thus ensuring that your design will operate with the same timing you determined from the logic element's specifications, regardless of how the circuit is actually arranged in the array.

The FPGA2020 array costs $83 (100) in a ceramic windowed DIP. The design software, including a schematic-capture feature, a library, and a device programmer, costs $3495. The software runs on 80286 or 80386 MS-DOS-compatible computers and supports Viewlogic and Orcad software.—Richard A Quinnell

UPGRADED ADA COMPILER QUADRUPLES PERFORMANCE

Revised versions of the Telegen2 Ada compiler from Telesoft AB (San Diego, CA, (619) 457-2700) generate code that runs as much as four times faster than code generated by previous versions of the compiler. The company offers a host development system (HDS) for generating VAX/VMS programs and a comprehensive development system (CDS) for generating programs that run on Motorola's 68000 μP family. Both development systems run on Digital Equipment Corp VAX computers. A run-time support package called Turbo RSP provides the speed boost and can perform an Ada rendezvous task switch in 65.2 μsec (as measured by the Performance Issues Working Group test TOOO007) when run on a 68030-μP-based target system.

Both the HDS and CDS include source-level debuggers that let you examine your source code while your compiled program is running on the target system. Both development systems also include an Ada profiler that can help you find and improve inefficient portions of your program. The CDS can generate object files that conform to the IEEE-695 object module format, thus letting you use in-circuit emulators from vendors such as Cadre's Microcase Div, Hewlett-Packard, and Tektronix. Prices for the HDS and CDS start at $4200 and $10,500, respectively.—Steven H Leibson

CIRCLE NO 30

C107-2 REV. ORIG.

eg Technology

WE'RE BUILDING FOR THE FUTURE BECAUSE THEY'LL NEED TO REMEMBER TOO.

We supply many of the memory chips needed today, and already we're looking at how best we can meet the needs of tomorrow.

We currently offer two types of 256K DRAMs: 64K x 4 and 256K x 1. We have them in DIP or PLCC packages. And we have them in quantity.

We've also just added a 1M x 1bit CMOS DRAM to our list.

And having just completed a fourth wafer fab facility that includes a 6″ wafer fab line and a new R&D complex, we'll soon be able to offer an even wider choice of DRAMs.

DRAMs

Description	Part #	Package Options*	Access Time, nsec	Availability
256K x 1, Fast Page	HY53C256	DIP, PLCC	70, 80, 100, 120	NOW
63K x 4, Fast Page	HY53C464	DIP, PLCC	80, 100, 120	NOW
1M x 1, Fast Page	HY51C1000	DIP, SOJ	100, 120	Samples: NOW Production: 1Q90
1M x 1, Static Col	HY51C1002	DIP, SOJ	100, 120	Samples: NOW Production: 1Q90
256K x 4, Fast Page	HY51C4256	DIP, SOJ	100, 120	1Q90
256K x 4, Static Col	HY51C4258	DIP, SOJ	100, 120	1Q90

*Tape and reel available for all surface-mount packages

We're continuing to build, because we're committed to the U.S. semiconductor market, and of course, to the generations to come.

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Send me data packs on (please check the appropriate box): ▲ Hyundai DRAMs ▲ Hyundai SRAMs ▲ Hyundai 1K EEPROM ▲ Send my free Hyundai Semiconductor Databook.

Hyundai Semiconductor, 166 Baypointe Parkway, San Jose, California 95134.

HYUNDAI SEMICONDUCTOR

SIGNALS & NOISE

His theory should increase energy

Four years ago I developed a mathematical derivation of electrons, quarks, protons, and neutrons from the basic assumption of four isotropic and homogeneous dimensions. In doing so, I found the physical causes of gravity to be strong, weak, and electromagnetic forces. This grand, unified field theory also had some interesting insight into the big bang and astronomy. And it explained why the periodic table of the elements is the way it is.

Using this theory, two simple changes to the Pons-Fleischmann device will increase its energy more than a hundredfold. But as Jon Titus pointed out in his editorial (EDN, June 22, 1989, pg 65), this device may not be the solution to our energy needs. This theory also explains what matter and antimatter are physically and how they can be created and used to produce energy directly. This postulate would be the ideal solution to our energy needs.

When I tried to get this theory published, all I got was laughs. I offered its energy source application free to General Electric when I worked there. The company's reaction was to pronounce a "Not-Invented-Here Syndrome." When the SDI (Strategic Defense Initiative) was starting, I offered it to them free. They said to call them when I had a working system. I offered it free to Rockwell International for use as an energy-impulse engine for space flight (actually for all forms of transportation). The person reviewing it called it science fiction, yet the math was there.

Granted, some of their disbelief could come from the fact that I'm a software design engineer and not a theoretical physicist by profession. But it was precisely my software training that allowed me to recognize the binary nature of the universe and to decode the quark structures. Everything else then fell into place.

I feel the Utah researchers did what they could only do to circumvent the egos of the establishment—call a news conference.

Why don't I do the same? Why should I? There's no money in it for me, just a lot of aggravation. And I'd rather spend my time breeding horses than spend time providing the world with unlimited food, water, and energy.

Steven L Comee
Thousand Oaks, CA

Get it in writing

After reading about foreign assignments in your magazine, I thought you might like to hear a horror story of what can happen to engineers in foreign countries. My experience was with a large, well-respected company.

First, you must realize that once you're in a foreign country, you become totally and completely dependent upon your company for everything: living quarters, mail, problems with work permits, taxes, foreign law. Second, once you're in a foreign country, you have absolutely no bargaining powers.

Now you must imagine what happens if your company decides to change any part of the agreements or understandings that were made stateside. I hope the scenario is becoming clear because it happens regularly.

For instance, your foreign bosses decide that you really don't need a car, or that your children really don't need to go to school, or that you really should pay foreign taxes.

You now have one of two choices—take it or leave it. And the situation gets worse. You're in legal limbo. The US Labor Department won't touch it, the Better Business Bureau will not (cannot) touch it, and the US State Department will look the other way. Adding insult to injury if you do decide to walk out for any reason (sign this letter of resignation if you want a plane ticket home!), your career is seriously damaged. You're landed back in the States professionally and financially (and in my case, physically) crippled. Anyone out there considering a foreign assignment should

- Get everything you are promised in writing. This includes everything you would normally take for granted, like being able to park in the company's parking lot.
- Demand to talk to someone already on assignment at the location in question.
- Attempt to find out about the cost of living in the area. Big dollars do not mean much in Munich where you can divide your salary in half to see how you'll really be living ($50,000 there ≈$25,000 here).

To sum it up, what sounds like a dream position (almost too good to be true) can and often does become your worst nightmare. I am not alone.

I hope you'll print this to warn others because there doesn't seem to be any other forum.

William A Stroup Jr
Las Vegas, NV

Be responsible, and don't tolerate mediocrity

Jon Titus's editorial entitled "She'll be right, mate"(EDN, October 12, 1989, pg 49), is right on target about what is causing severe erosion of this country's ability to maintain a competitive edge in commerce, education, and leadership. Irresponsibility, as Jon pointed out, is the fundamental cause of such erosion; also, we tolerate mediocrity in everything.

In addition to your examples of irresponsible behavior, here are two more: the substitution of "there you go" for "thank you" at the check-out counter, in restaurants,

and in many other places; and the flagrant disregard for simple rules, such as not parking at red and yellow curbing at malls and in spaces reserved for handicapped drivers and passengers. Even our language, spoken and written, shows erosion and deterioration for the sake of abbreviated talk; for example, expressions such as a slurred "bye" for "good-bye," "uh-huh" for "yes," and "OK" for all assenting expressions. I have even heard teenagers say, "I'm not going to do it, OK?" To me, that sounds as if they're using "OK" to say "No."

I can also see why some school-age children cannot learn to read, write, or talk correctly. The reason is because they spend 60 to 70% of their free time in front of a TV set. TV programs are not educational anymore with their use of such expressions as "lite" for light and "nite" for night.

Keep up your exceptional work, and thanks—"I needed that." So do many, many others in this country of ours.

Jess Cabello, EE, PE
San Antonio, TX

Reader points out more Micro Channel features

We read with interest the article "Micro Channel Interface ICs—Board's functions determine IC choice" (EDN, June 8, 1989, pg 71). Although we realize that it's difficult to cover all the features and functions of the many Micro Channel devices in the marketplace, we feel that some significant features of Standard Microsystems' MCI94-C18 that are worthy of mention were omitted from the article.

For example, the article points out that Vector Electronics offers a Micro Channel development board to its customers at a cost of $350. SMC, however, offers an equivalent development board free of charge to potential customers.

Although some features of the

Micro Channel device were elaborated on in the article, and are also featured in the SMC product, we feel that some other key features of the MCI94C18 that are essential in making the purchasing decision of any Micro Channel device, should also be pointed out. These features include

- Programmable wait generators—The MCI94C18 includes circuits that generate wait states for extending I/O or memory cycles independently.
- Interrupt mapping circuit—The MCI94C18 includes circuitry that takes four interrupt signals from the peripheral and maps them into four IRQ signals on the Micro Channel.
- PC/AT-style control signals are also offered in the device.
- Flexible DMA interface—The MCI94C18 provides a flexible DMA interface with software-generated DMA register. In addition, hardware and software requests can be ANDed or ORed to offer flow control.
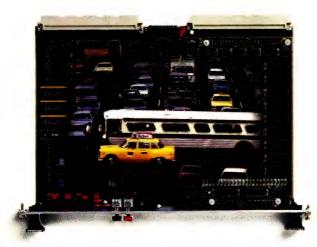
Standard Microsystems Corp also offers a special-function Micro Channel interface, called the MSD95C10 Midas. This device provides a cost-effective solution for the design of Micro Channel to PS/2 hard-disk adapter boards. The MSD95C10 provides all the handshaking signals required by the Micro Channel bus and serial interface logic for ESDI hard-disk drives.

Donna Weaver
Marketing Communications Manager
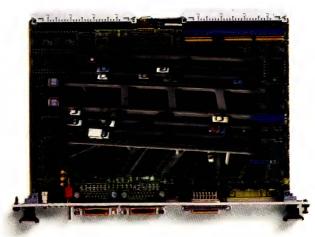*Standard Microsystems Corp*
Hauppauge, NY

WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

CALENDAR

The International Conference on CAD/CAM and AMT in Israel, Jerusalem, Israel. Dr Lawrence R Odess, Dept 9621, Israel Aircraft Industries, 70100 Ben Gurion Airport, Israel. (972-3) 971-3991. December 11 to 14.

1989 289th IEEE Conference on Decision & Control, Tampa, FL. Leonard Shaw, Dept of Electrical Engineering and Computer Science, Polytechnic University, 333 Jay St, Brooklyn, NY 11201. (718) 260-3802. December 13 to 15.

ATE & Instrumentation West, Anaheim, CA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. January 9 to 11.

Supercomputing Europe '90, London, UK. In the US, Mr Gerry Parker, Meridien Pacific Group, 116 E Blitdale Ave, Suite 2, Mill Valley, CA 94941. (415) 381-2256. FAX 415-381-1451. In Europe, Mr Fetze Pijlman, Royal Dutch Fairs, Box 8500, 3503 RM Utrecht, The Netherlands. (31) 30-955285. FAX 31-30-940379. January 10 to 12.

OE/LASE '90—Optics, Electro-Optics, & Laser Applications in Science and Engineering/Exhibit, Los Angeles, CA. The International Society for Optical Engineering, Box 10, Bellingham, WA 98227. (206) 676-3290. FAX 206-647-1445. January 14 to 19.

Winter 1990 UNIX Technical Conference, Washington, DC. Judith DesHarnais, USENIX Conference Office, 22672 Lambert St, Suite 613, El Toro, CA 92630. (714) 588-8649. January 22 to 26.

SaudiComputer '90, Saudi Arabia. Gerald G Kallman, Kallman Associates, 5 Maple Ct, Ridgewood, NJ 07450. (201) 652-7070. FAX 201-652-3898. January 28 to February 1.

WE'VE REDUCED EVERYTHING BUT THE PERFORMANCE

CALENDAR

SECS Communications Seminar, Dallas, TX. GW Associates Inc, 1183 Bordeaux Dr, Suite 27, Sunnyvale, CA 94089. (408) 745-1844. February 2.

Hands-on UNIX for Programmers (short course), Seattle, WA. Specialized Systems Consultants Inc, Box 55549, Seattle, WA 98155. (206) 527-3385. FAX 206-527-2806. February 7 to 9.
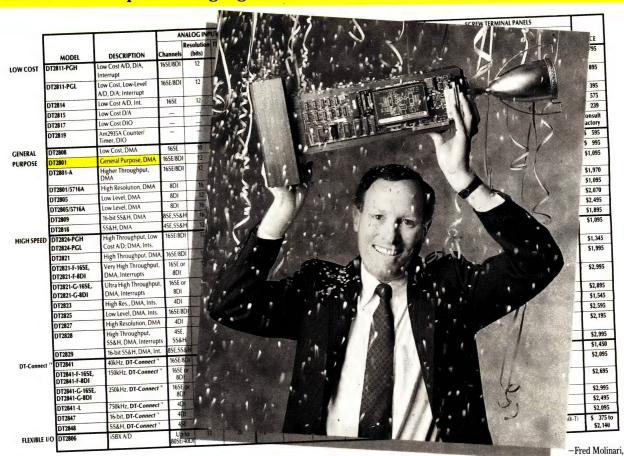
1990 Symposium on Electronic Imaging: Science and Technology/Exhibit, Santa Clara, CA. The International Society for Optical Engineering, Box 10, Bellingham, WA 98227. (206) 676-3290. FAX 206-647-1445. February 11 to 16.

Systems/USA, San Jose, CA. Chuck Jungi, American Electronics Association, 5201 Great America Pkwy, Santa Clara, CA 95054. (408) 987-4204. February 13 to 15.

Modern Power Conversion Design Techniques (short course), San Diego, CA. Joy Bloom, Bloom Associates Inc, Educational Div, 115 Duran Dr, San Rafael, CA 94903. (415) 492-8443. FAX 415-492-1239. February 19 to 23.

Compcon Spring '90, San Francisco, CA. Dr Kenichi Miura, Fujitsu America, 3055 Orchard Dr, San Jose, CA 95134. (408) 432-1300 ext 5408 or 5723. February 26 to March 1.

Advances in Semiconductors and Superconductors: Physics Toward Device Applications and Exhibit, San Diego, CA. The International Society for Optical Engineering, Box 10, Bellingham, WA 98227. (206) 676-3290. FAX 206-647-1445. March 17 to 21.

SONY TAKE COMMITMENT TO

FAST CACHE.
*Cache memory for Intel 80386.
Also standard SRAM line
down to 8K x 8 @ 20 ns,
16K x 4 @ 15 ns.*

What you see here is a demonstration of Sony's intense commitment to your each and every SRAM need.

A commitment made even more impressive by the fact Sony's only been engineering and producing SRAMs for just over five years.

And when you consider we're pouring all our resources into SRAM technology—including a new production facility in Nagasaki, Japan—this demonstration merely hints at the Sony SRAM technology yet to come.

Ultra-high speed cache.

Via a unique 0.8-micron process, Sony covers your fast processor cache-memory needs two distinct ways.

First, there's our Model CXK7701J, designed specifically for the Intel 80386.

This application-specific memory (ASM) combines address

ULTRA-HIGH SPEED CACHE SRAMS			
MODEL	CONFIG.	SPEED (ns)	PACKAGE
CXK7701J*	8K x 16	30/35/45/55	PLCC
CXK5863AP	8K x 8	20/25/35	DIP 300 mil
CXK5863AJ	8K x 8	20/25/35	SOJ 300 mil
CXK5466P	16K x 4	15/20	DIP 300 mil
CXK5466J	16K x 4	15/20	SOJ 300 mil
CXK5467P**	16K x 4	15/20	DIP 300 mil
CXK5467J**	16K x 4	15/20	SOJ 300 mil
*For Intel 80386.	**O/E		

latch, memory and transceiver within one IC. Ready for user configuration as either an 8k x 16-bit memory or as two 4k x 16-bit memories.
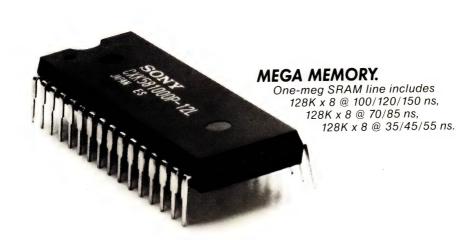
Second, consider our new ultra-high speed SRAM capabilities.

As you scan the chart above, keep in mind even higher speeds will be available soon.

S ITS SRAM THE EXTREMES.

MEGA MEMORY.
*One-meg SRAM line includes
128K x 8 @ 100/120/150 ns,
128K x 8 @ 70/85 ns,
128K x 8 @ 35/45/55 ns.*

Ultra-high density.

Sony solves your board-space problems with three new 1-Mbit SRAMs.

Each is based on our 0.8-micron CMOS technology. Configured as 128K x 8 bits. And available in 32-pin DIP and surface-mount plastic packages.

And not only do Sony 1-Mbit SRAMs maximize board space, but process speeds as well.

HIGH-DENSITY SRAMS			
MODEL	CONFIG.	SPEED (ns)	PACKAGE
CXK581000P	128K x 8	100/120/150	DIP 600 mil
CXK581000M	128K x 8	100/120/150	SOP 525 mil
CXK581001P	128K x 8	70/85	DIP 600 mil
CXK581001M	128K x 8	70/85	SOP 525 mil
CXK581020SP	128K x 8	35/45/55	DIP 400 mil
CXK581020J	128K x 8	35/45/55	SOJ 400 mil

Nowhere else will you find a greater choice: 100/120/150-ns, 70/85-ns and 35/45/55-ns speed figures.

Sony SRAMS cover the performance spectrum.

Sony offers well over one hundred SRAM solutions, covering the entire performance spectrum.

All competitively priced, all shipping now.

So call Sony with your most demanding SRAM spec.

We'll go to the extremes to deliver.

For complete details, call Sony at (714) 229-4190 today. Or write Sony Corporation of America, Component Products Company, 10833 Valley View Street, Cypress, California 90630, Attention: Semiconductor sales. FAX (714) 229-4285.

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EDITORIAL

Send your surplus to college

Surplus parts and equipment have played an important part in my electronics education. While I was in college, my school received donated stepper switches, relays, circuit boards, and a host of other electronic equipment. Using some of it, three of us at the fraternity house I lived in built a rudimentary dial-telephone system that linked several rooms. By designing and building our own phone system with parts at hand, we learned a lot about switching circuits, power supplies, and oscillators.

I've always thought that the best part of learning electronics lies in actually building and debugging circuits. So, it's unfortunate that there are few remaining outlets for surplus electronic equipment. Today, many high-school and college students miss out on the fun of electronics because few experimenter publications endure and sources of cheap parts and equipment are few and far between.

However, one part of that situation has changed thanks to the surplus-exchange program at the Gifts-In-Kind Clearing House in Davidson, NC. Set up six years ago, the nonprofit organization works with donors and recipients to match donations with the needs of schools, colleges, and other nonprofit organizations. The clearing house has seven warehouses around the US that can accept surplus equipment and parts of all kinds. And the group handles much more than electronic equipment. For example, Corning recently donated four truck loads of Corningware, and the Cochrane Furniture Company donated 150 pieces of furniture—enough to outfit a small dormitory.

Many companies already donate equipment to local colleges, but those gifts may be a poor match with the college's needs. By donating surplus equipment and parts to the clearing house instead, you'll ensure that the donations go to an organization that can use your gifts. Donations also benefit the donors. Under sections 170(E)(3) and 170(E)(4) of the IRS Code, donors can claim a tax deduction of as much as 200% of each donated item's cost.

To help support the program, colleges and charitable organizations involved with the program must pay a yearly fee of $1000 to the clearing house. But in light of the possible benefits, that's a small sum. Companies interested in supporting a local university could donate the yearly fee to get the university into the program. We support the clearing house's objectives, and we urge you and your company to support them, too. For more information about the Gifts-In-Kind Clearing House, phone Manager of Contributions John Lee at (704) 892-7228 or send him a fax at 704-892-3825. The group's mailing address is Box 850, Davidson, NC 28036.

Jesse H Neal
Editorial Achievement Awards
1987, 1981 (2), 1978 (2),
1977, 1976, 1975
American Society of
Business Press Editors Award
1988, 1983, 1981

Jon Titus
Editor

Logic In For The

Westinghouse military systems engineers replaced four 22V10 PALs and six MSI devices with a single ACT 1010 part, handling the entire error correction, registration, and interface logic for their high speed, high dynamic range A/D converters. Schematics were captured on a Mentor system, and implemented with the Action Logic System (ALS). The design utilized 224 out of 295 logic modules.

Maxtor engineers use Actel's ACT 1010 chips and the Action Logic System software to quickly create and modify new disk drive electronics. They've produced nine different designs, with 85% to 95% gate utilization. During seven months of intensive work the ALS software has never crashed or lost data, and the system has produced every part as designed.

Actel Field Programmable Gate Arrays.

Let's face it. When it comes to programmable ASICs, greed is just good engineering. The best engineers are always hungry for more. More logic. And more different kinds of logic. All on one chip.

More is exactly what you get with Actel's ACT™1 field programmable gate arrays.

They're a whole new technology designed specifically for logic integration. Not just another brand of EPLD, PAL®, or LCA™ chip. They combine a true chan-neled gate array architecture with Actel's revolutionary PLICE™ antifuse programming element—resulting in 85% gate utilization. Guaranteed.

But you not only get more with Actel, you also get less. Less work, thanks to 100% automatic place and route. Less

Actel's complete logic solution includes the Action Logic™ System (ALS) software, a programming module, and 1200- or 2000-gate ACT 1 programmable gate arrays.

EDN December 7, 1989   **CIRCLE NO 71**   47

Just as logic and spectrum analyzers evolved from Tek scopes, now so does the Digitizing Signal Analyzer: thanks to Tek's proprietary digital signal processing chip, it is the first instrument to make real-time measurement and analysis practical at the highest acquisition speeds.

First of a new class of high-performance analysis tools, the DSA 600 Series combines the fastest acquisition speeds— 1 GHz bandwidth, 2 GS/s sampling—with superb resolution and accuracy integrated between the instrument's digitizing and display processors.

Experience the DSA's phenomenal speed for yourself. In front-end acquisition. In waveform processing and analysis.

	DSA 601		DSA 602		
Sample Rate	500 MS/s	1 GS/s	500 MS/s	1 GS/s	2 GS/s
Number of Channels	2	1	4	2	1
Record Length per Channel (Points)	512-10K	512-20K	512-10K	512-20K	512-32K
Nyquist Bandwidth	250 MHz	500 MHz	250 MHz	500 MHz	1 GHz
Repetitive Bandwidth	1 GHz		1 GHz		
Vertical Resolution	8 Bits		8 Bits		

and an unprecedented set of waveform math and analysis capabilities.

These include real-time FFTs. Calculated gain and phase. Complex transformations. Averaging and smoothing. Processing capabilities you've never seen "live," if at all, on an oscilloscope before—all made possible by Tek's own TriStar™ Processor
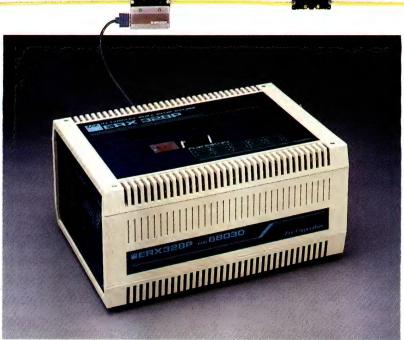
In streamlined operation that lets you capture, measure, analyze, label, and output waveforms like they're standing still.

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We now invite you to witness the next generation of microprocessor development tools by introducing *high speed 33 MHz support for 68020 and 68030,* and by presenting *'AXIS,' a revolutionary configuration featuring an ethernet interface for networking ERX-series emulators with Sun* *workstations.* We've enhanced the ERX configuration without forfeiting the ergonomic features and compact size we've always provided. You now get higher speed and more versatility in addition to features like one million breakpoints, two meg of emulation memory, performance analysis, source level and symbolic debug, enhanced window driven interfaces, and full cross development software, to name a few.

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ZAX
Zax Corporation

PLD design software eases combination of schematic and text-based designs

Designers working with the Max (multiple array matrix) family of erasable PLDs (EPLD) now have a design tool available that simplifies movement between text- and schematic-based design descriptions. Max+Plus version 2.0 provides a context-sensitive editor that automatically switches between text and graphics modes as you create and edit your design.

The program handles the full range of tasks needed for EPLD design: design entry, compilation and logic synthesis, error checking, timing analysis, simulation, and device programming. It runs under DOS version 3.3 on an IBM PC/AT or a compatible computer with 640k bytes of RAM, a 20M-byte hard-disk drive, a serial mouse, and an IBM EGA and VGA, or a Hercules monitor. It also requires a full-size 8-bit card slot for the programming hardware.

You can create your design using schematics, Boolean equations, a hardware description language (HDL), or any combination of the three. The software also accepts data from other CAD programs in the electronic data interchange format (EDIF).

The HDL allows you to design at a high level of abstraction, using operators to describe how the logic functions. For example, you can define an array of address lines, then describe an address decoder using arithmetic, relational, and conditional operators such as Add or Compare. You can also use Case statements to describe state-machine designs. The HDL accepts Include commands that allow you to create design macros for frequently used functions.

If you prefer to use schematic

*A **context-sensitive editor automatically switches** between text and graphics displays in this PLD design program. You can freely mix schematics, equations, and hardware-description-language designs in the same edit session.*

representation, the program offers a library of schematic elements from the 7400 logic family. Because the design software supports hierarchical design, you can also define your own library elements.

The context-sensitive editor allows you to create your design, using a mix of description formats. The software generates a schematic element for each design section you create in text form. You can also define schematic elements that represent sections of your circuit's schematic such as functional blocks. You can then manipulate these schematic elements as part of a higher level design. As you move up and down this design tree, the editor automatically switches between text and graphics modes, allowing you to edit the element in the appropriate format.

The program also offers delay prediction and error-checking capability while working within the edi-

tor. The delay predictor provides you with the range of possible delays on each net selected, allowing you to determine the critical paths in your design. The error checker highlights the nets connecting elements that have an electrical or syntax error in their definition so that you can quickly identify and correct problems.

The software supports the Max family of EPLDs. You can order PLDS-Max, which includes the software, programming hardware, and device adapters for two types of EPLDs, or PLDS-Encore, which supports all types. PLDS-Max costs $4995; PLDS-Encore costs $7995. Software only sells for $3400 and is free to customers holding a software warranty agreement.

*—**Richard A Quinnell***
Altera Corp, Box 58163, Santa Clara, CA 95052. Phone (408) 984-2800.

Circle No. 735
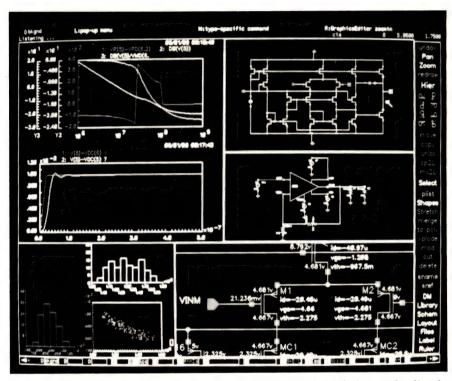
Integrated software tools and simulation flexibility speed IC design

The Artist Analog Design System makes you more productive by providing a design system that integrates schematic capture, simulation, and layout in one software package. To create a good design package, however, you should also have a good simulator. Artist offers you two choices: Cadence-Spice or an option, HSpice from Meta-Software.

Cadence-Spice is a version of Berkeley Spice with modifications to improve convergence and flexibility. You can use this Spice simulator to stop a simulation, examine results, and restart the simulation, as well as restart the simulation from a previous solution. Furthermore, you can measure currents without inserting an ammeter function in your design. The simulator provides automatic detection of transient transistor saturation. The software also gives you full plotting capability, including the ability to overlay multiple-simulation results.

Using Artist's integrated system can also make a difference in your productivity when you have data that must traverse the schematic, simulation, and layout functions. For example, the software can back-annotate node voltages and currents from the simulation to the schematic. In addition, you can extract the parasitic layout-generated LCR and resimulate, using this data. The system allows you to do a layout vs schematic check on line, and a cross-probe capability correlates a location on the schematic with the corresponding location on the layout.

Artist also helps you build flexible-function libraries by allowing you to define component values that

The Artist Analog Design System features back-annotating of simulation results directly onto the schematic and flexible plotting options.

use mathematical expressions instead of fixed values. For example, in an IC design that requires a filter, you might designate a frequency and quality factor. By using mathematical expressions to set the resistance and capacitance values as a function of the frequency and quality factor, you would have a generalized filter function that's usable over a range of frequencies and quality factors.

If all these capabilities of the software appear overwhelming, a design-flow overlay guides you in the effective use of Artist tools.

The Artist analog-design system is not meant for mixed analog and digital simulation where feedback between analog and digital sections exists. However, the system is suit-able for designs where the analog and digital functions are separate, and it can be integrated with the vendor's digital-design tools.

Artist runs on Sun, Apollo, DEC, and Sony workstations. The software package is available now and is priced at $30,000 per seat. Analog upgrades to existing seats cost $18,000.—***Doug Conner***

Cadence Design Systems Inc, 555 River Oaks Pkwy, San Jose, CA 95134. Phone (408) 943-1234. FAX 408-943-0513.

Circle No. 737

At last, a real breakthrough in PLD design

What would the perfect PLD design software include?

Some problems are better solved using truth tables. Others could use a procedural language for state machines. Boolean equations are certainly necessary. Simplifying and condensing equations, especially repetitive ones, would be great.

OrCAD/PLD can do all of that.

It would have to work within schematics so documentation would all be in one place.

OrCAD/PLD does that, too.

For output, you need to have a JEDEC file for PLDs and a hex file for PROM burning.

It's easy with OrCAD/PLD.

And logic synthesis? You don't want to buy extra hardware to handle something as complex as that.

OrCAD/PLD offers a whole new way of design expression called numerical mapping. Its the most powerful means for designing PLDs on any platform , yet it runs on a standard PC.

The perfect programmable logic design software shouldn't cost a lot.

Accepts multiple inputs, including truth tables, state machines, Boolean equations, indexed equations, schematic entry and numerical mapping.

OR8873-INTL

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CIRCLE NO 77

Tape drive fits 3½-in. form factor and stores 600M bytes on a data cassette

A 600M-byte tape drive based on the data cassette now offers system designers an alternative to quarter-inch cartridge or helical-scan tape drives. The Model MT2ST/F drive transfers data at 242k bytes/sec, achieves its capacity using no data compression, and fits in a 3½-in. drive bay. Furthermore, the drive costs $550 (1000), making it far less expensive than comparable DAT (digital audio tape) or cartridge drives.

Proponents of the data cassette have always believed that the cassette medium offers better tape handling and positioning than cartridge drives offer. Because the cassette drive has direct control of both tape reels, it virtually eliminates the instantaneous speed-variation problem in cartridge drives. The MT2ST/F also positions the tape accurately enough to store data on 21 tracks across tape only 0.15 in. wide.

The MT2ST/F drive employs a variation of double-density NRZI (nonreturn to zero, invert on ones) data recording that adds a pulse train in the data stream to eliminate peak shifts in the signal. The recording scheme yields a recording density of 48,000 flux transitions/in. And GCR (group coded recording) 4/5 data encoding results in a bit density of 38,400 bpi.

A 2-track, dual-gap ferrite head allows the drive to do read after write verification of data. The drive records data one track at a time in a serpentine manner and also includes a full-track erase head. The product features a hard error rate of less than 10_{12} and also includes an Exclusive-Or-based error-correc-

Recording 600M bytes in 42 minutes, the MT2ST/F data-cassette drive offers capacity and performance comparable to DAT or high-end QIC tape drives.

tion-code scheme that adds only 11% overhead.

The tape speed of 60 ips yields the 242.3k-byte/sec transfer rate and allows the drive to back up 600M bytes in 42 minutes. The data format employs 1024-byte blocks. You can choose from SCSI or QIC-02 (quarter-inch cartridge) controllers for the drive, and either choice includes a 64k-byte buffer.

The MT2ST/F uses a cassette with 600 ft of 900-Oe tape but retains downward-read compatibility with earlier 60M- and 160M-byte drives. You can eject cassettes manually or via software control. The product offers an MTBF of 10,000 hours. The company plans to ship small volumes of the drive in January 1990 and production quantities by the end of the first quarter.—*Maury Wright*
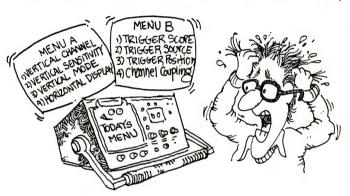
Teac America Inc, 7733 Telegraph Rd, Montebello, CA 90640. Phone (213) 726-0303. FAX 213-727-7621.

Circle No. 736

"USER-FRIENDLY" IS THE WATCHWORD FOR TODAY'S OSCILLOSCOPES.

Recent advances in oscilloscope technology have proceeded at a very rapid pace. Almost across the board these advances have been beneficial. In these "high-tech" units, manufacturers have held out the promise of a scope loaded with every feature under the sun. And from auto setup to menu select capabilities, every function is shown to be ac-

cessible at the touch of a button. But a true reading of a scope's user-friendly potential cannot be obtained until the scope is applied to an actual project. Only at that point can it be determined how much time it will take to gain full use of the oscilloscope.

A new unit may allow work to proceed without a hitch. But where things haven't gone smoothly, situations similar to this have been reported. Turn on the new unit and a menu immediately appears. Should horizontal display, triggering, channel coupling, or another of the many alternatives listed be chosen? Triggering is chosen, but then a sub-menu is displayed. Now a decision has to be made among trigger source, trigger coupling, trigger slope, etc. Okay, trigger source is opted for and set. Now, if information from another menu is needed, trigger source must be exited and the needed menu brought up. With all this going on, the engineer may become distracted from the task at hand — the close observation of waveforms on the screen.

This potential for confusion points up exactly why careful examination has to be made when equipment is advertised as user-friendly. A closer look may reveal that sophisticated, menu-driven scopes are not always the easiest to operate. A new scope that builds and improves on controls that are already being used efficiently may turn out to be the most user-friendly. Toward this end, a number of features have been developed that improve the efficiency and precision of conventional oscilloscopes. Among these features are cursors with digital readouts, auto ranging, and relative hold-off, to name a few.
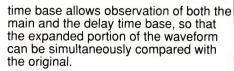
CURSORS WITH DIGITAL READOUTS — A QUANTUM LEAP IN EFFICIENCY

One user-friendly breakthrough, in terms of both speed and accuracy, has been the development of cursors.

Whereas older scopes required counting graticule divisions, cursors now allow measurements to be displayed digitally. Cursors supply readouts such as time, voltage, frequency, and phase, plus time and voltage difference ratios. Time difference ratio is ideal for performing phase shift measurement. With voltage difference ratio, the measurements of waveform overshoot can be made. The cursors make measurement of waveform parameters more consistently accurate.

On-screen readouts provide a constant reminder of operating conditions and keep a record of these settings in waveform photographs. Many important settings are displayed, including TV field/line setting, which expands the oscilloscope to video-related applications.

AUTO RANGING AIDS TIME BASE SELECTION

Of great help is a scope that offers both auto ranging and alternate time base. Auto ranging selects from 22 possible time base settings to display an optimum number of cycles. This is another feature that makes an oscilloscope a bit more user-friendly. Alternate time base allows observation of both the main and the delay time base, so that the expanded portion of the waveform can be simultaneously compared with the original.

ANOTHER FEATURE TO CONSIDER CAREFULLY — DOES THE WARRANTY HAVE TEETH?

Another factor that needs to be examined just as closely as those mentioned previously is the warranty. In competing for market share, longer and more extensive warranties are offered every year. Before basing a decision only on warranty, though, consider its true value if the equipment is not reliable. Remember, no warranty can make up the cost of a scope that's out for repairs for 4 to 6 weeks, or more. That's why even more important than the actual wording of a warranty is the reliability that's built into every oscilloscope. Ideally, of course, no piece of equipment should ever break down. But if a unit needs repair, it's important to know who provides the fastest turnaround time in the industry.

Now there is an oscilloscope whose user-friendly format includes all the features discussed earlier, plus many more. This unit, introduced by Leader Instruments Corporation, is the 100 MHz CRT readout with cursors, Model 2100R. The unit is easy to use and also incorporates these additional features: TV full-line selection, alternate triggering, and relative hold-off. This and every other Leader product come with an iron-clad 2-year warranty, which is backed by a return rate of less than 1% during the warranty period and a very rapid turnaround time. In other words, the 2100R offers a complete oscilloscope package.

For more information or Leader's full-line catalog, call toll free: 1 800 645-5104. In NY call 516 231-6900. Or write Mike Hoyer at Leader Instruments Corporation, 380 Oser Avenue, Hauppauge, NY 11788.

100 MHz CRT readout Model 2100R from Leader Instruments Corporation.

Circle 10 for Product Information   **Circle 11 for Product Demonstration**

Microcontrollers have 1-cycle instructions and selectable speed and power combinations
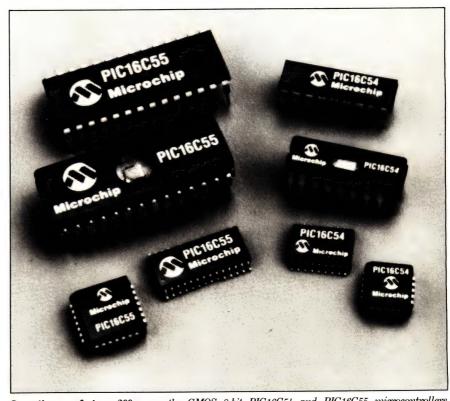
If your embedded control application requires high speed or low power without a lot of complexity, consider the PIC16C54 and PIC16C55 8-bit CMOS microcontrollers. Their RISC-like architecture gives the microcontrollers a lot of performance in a small package.

The devices include 512×12 bits of program EPROM, 32 8-bit registers, a counter/timer, a watchdog timer, a timer prescalar, and bidirectional I/O ports. The PIC16C54 has 13 I/O lines, and the PIC16C55 has 21. An on-chip oscillator allows you to use either a crystal or an RC network to generate the system clock. The watchdog timer has its own oscillator, allowing it to continue operating even if the processor oscillator is stopped.

The microcontrollers use a 12-bit mixed instruction/data word and a 2-stage pipeline to achieve single-cycle instruction execution. (An instruction cycle is four clock cycles.) The instruction set includes bit- and byte-oriented file register commands, arithmetic and logic operations, and control commands. Data or operands such as register addresses form a part of each instruction word.

Depending on your needs, you may choose from three clock/oscillator frequency ranges to control power consumption. The lowest speed, 400 kHz, requires only 1 mA with a supply voltage of 3.5 to 6V. At 4 MHz the device's current draw is 1.8 mA; at 20 MHz, the draw is 24 mA.

The device also offers a software-commandable sleep mode that stops the processor clock and reduces current draw to 5 µA. You can reactivate the processor by toggling a

Operating as fast as 200 nsec, the CMOS 8-bit PIC16C54 and PIC16C55 microcontrollers feature single-cycle instructions, pipelining, and a RISC-like architecture. Their 12-bit instruction words include both operator and data.

control line or by allowing the watchdog timer to complete its cycle. The timer's normal period is 1.8 msec. By using the prescalar, you can extend the period to 2.5 sec.

Two types of programming tools are available for the PIC16C54 and the PIC16C55. The company offers its PIC Pak, an assembler/software simulator that runs on an IBM PC or compatible computer, together with a programmer board. A third-party vendor, Microindustrie (San Diego, CA) offers its Pices III system for the microcontrollers. The system includes an assembler, a software simulator, and an in-circuit emulator.

The microcontrollers are avail-able in a variety of styles. You can choose between UV-erasable and one-time-programmable devices. Package styles include plastic and ceramic DIPs, SOICs, and plastic leaded-chip carriers.

In a 4-MHz plastic DIP, the PIC16C54 costs $2.40, and the PIC16C55 sells for $2.95 (2500). The price of the PIC Pak is $495; Pices III costs $1995.

—Richard A Quinnell

Microchip Technology Inc, 2355 W Chandler Blvd, Chandler, AZ 85224. Phone (602) 963-7373. FAX 602-899-9210.

Circle No. 733

First EISA plug-in board samples analog signals at a 12-bit, 1M-sample/sec rate

The first plug-in board for use with the Extended Industry Standard Architecture (EISA) bus is now available. The EISA-A2000 can suit your high-speed data-acquisition needs better than standard IBM PC-compatible computers can. It samples analog signals at rates reaching 1M samples/sec, digitizes each sample in 1 μsec with 12-bit resolution, and sends the data directly to memory using EISA burst-mode DMA transfers. Because the board transfers data to memory in short bursts of 16.5M bytes/sec, you don't have to worry about the board hogging the bus. In fact, even with multiple EISA-A2000 boards operating at full speed, your computer will have sufficient bandwidth left to service other devices you may have in your system.

Each of the board's four simultaneously sampled, single-ended analog input channels has its own S/H circuitry. This feature lets the board concurrently sample and acquire multiple signals, so you can precisely compare the amplitude and phase levels of as many as four different waveforms. The board can sample one channel at 1M samples/sec, two channels at 500k samples/sec, and four channels at 250k samples/sec.

You can initiate data acquisition using software, analog, or digital triggers. You can also program the EISA-A2000 to acquire data before and after a trigger condition occurs. Or you can program the board to inhibit the acquisition process until a specified time has elapsed after a trigger is received. You can also combine these pre-, post-, and delay-triggering modes to acquire

Providing four simultaneously sampled analog input channels with analog and digital triggering for high-speed level and phase analysis of multiple waveforms, the EISA-A2000 features a 1M-sample/sec rate with 12-bit resolution.

data before and after an analog or digital trigger. Using these triggers, you can make the board emulate an oscilloscope. You can even attach optional coaxial adapters to the board's input connectors, which permit you to plug oscilloscope probes directly into the board.

You configure and calibrate the board from software with a system configuration utility program. The board's address, DMA level, and interrupt level are programmable. It stores calibration data in EEPROM and maintains accuracy under varying time and temperature conditions. The calibration process requires no external connections, thus eliminating any need for manually setting jumpers, switches, or potentiometers.

Although the EISA-A2000 comes with documentation that permits you to program the board at the register level, you can purchase software that will greatly simplify the task. Using the VisionScope Virtual Instrument program, the board acquires the look and feel of a traditional oscilloscope, but offers 16 times the signal measurement
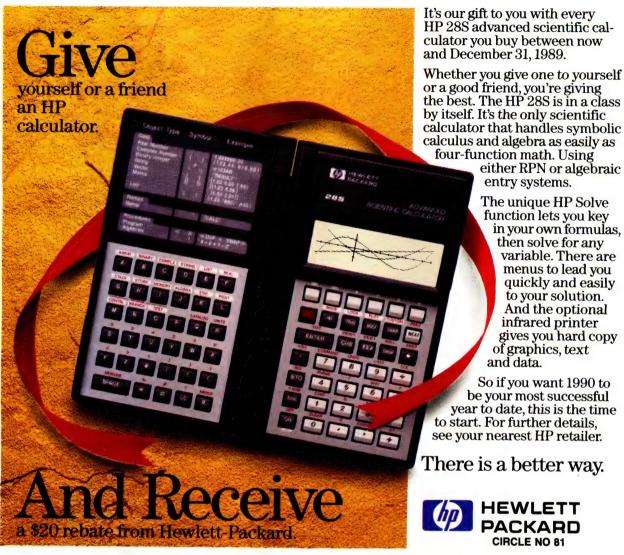
accuracy of most stand-alone digital scopes. VisionScope lets you capture waveforms and store them to disk, compare captured waveforms to incoming signals, view pretrigger and post-trigger information, zoom in on the waveform buffer, and make instantaneous voltage, time, and frequency measurements.

Another program called DOS LabDriver 3.0 provides a library of high-level software functions for programming the EISA-A2000. By simply calling a function from Microsoft C or Quick Basic, you can control analog input, triggering, coupling, configuration, and calibration. The manufacturer plans to offer its LabWindows software tools and libraries for the EISA-A2000 in 1990.

The EISA-A2000 sells for $2995. VisionScope and DOS LabDriver each cost $295. You can purchase an optional coaxial adapter with seven BNC connectors for $225 or a 1m coaxial adapter cable for $175. For connecting two to five EISA-A2000 boards, you'll need a real-time system integration bus cable that costs $25 to $50.—*J D Mosley*

National Instruments Corp, 12109 Technology Blvd, Austin, TX 78727. Phone (800) 433-3488; in TX, (512) 794-0100. FAX 512-250-9319.

Circle No. 732
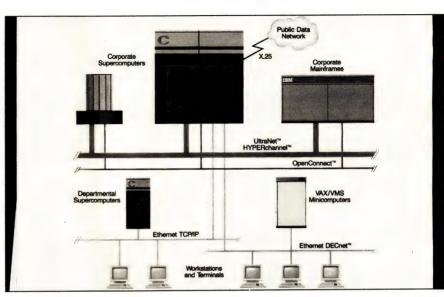
Supercomputing system provides corporate-wide access to 224-MIPS power

Now you can tap into the 200M-flops number-crunching capability of a Convex supercomputer from any terminal or computer in your company. The Open Supercomputing system of hardware and software products links your IBM mainframes, DEC VAXes, and engineering workstations to one of the manufacturer's integrated scalar, vector, or parallel-processing supercomputers.

The backbone of the Open Supercomputing network is the $28,000 UltraNet Interface, a data pipeline developed by Ultra Network Technologies that can communicate at 1G bps. Optimized for use with the ConvexOS operating system via a VME/UltraNet interface, UltraNet's software component handles all the network's data scheduling, trafficking, and buffering, thus leaving the Convex supercomputer's CPUs free for number-crunching applications.

ConvexOS includes utilities from Berkeley Unix 4.2 and 4.3BSD that provide your system with an interactive user environment, text processing, command interpreters, and optimized parallel processing. Furthermore, ConvexOS complies with IEEE's Portable Operating System Interface (POSIX) standard, making this company the only supercomputer vendor to provide POSIX-compliant Unix. ConvexOS Version 8.0 prices range from $7500 to $37,500 depending on your computer system's processor model and number of users. Via ConvexOS you can access more than 400 applications specifically for use with Convex supercomputing hardware.

To ensure that no single user monopolizes the network's CPU cycles, the Share Scheduler allocates CPU cycles over time in large com-

Open Supercomputing lets you link your corporate mainframe to one or more Convex supercomputers. For example, you can tie your IBM mainframe to Convex corporate and departmental supercomputers, VAX minicomputers, and an assortment of workstations via an UltraNet backbone, Hyperchannel network, OpenConnect bus, and Ethernet links.

puting environments. Depending on the processor model, you can buy the Share Scheduler for $7500 to $12,500. And for those who prefer a graphical icon-based user interface, you can use OSF/Motif to provide a common user interface across a wide range of applications.

The Enhanced Scalar Processor (ESP) increases the benchmark performances of the manufacturer's C Series of supercomputers by as much as 40%. Thus, a C240 supercomputer can deliver 200M flops and 224 MIPS. You can retrofit your C Series supercomputer with a $75,000 ESP upgrade. In addition, the $48,000 Integrated Disk Channel—based on the Integrated Peripheral Interface, Level 2 (IPI-2)—provides more than 20M bytes/sec of sustained data throughput and integrates as many as 32 IPI-2 disk drives for more than 200G bytes of data storage.

ConvexOS also eases movement of data, programs, and users from

one system to another by supporting the most popular protocols for integration of Unix systems into a distributed computing environment. Such protocols include Sun's Network File System, Apollo's Network Computing System, NASA's Network Queueing System, the X Window System, and Berkeley Unix 4.2. You can also access computers that use TCP/IP (Transmission Control Protocol/Internet Protocol) and DECnet protocols by utilizing a secondary Ethernet channel in the system. Communication with IBM's SNA (Systems Network Architecture) networks is possible using TCP/IP networks and a program called OpenConnect that was developed by Mitek Systems Corp.

—J D Mosley

Convex Computer Corp, 3000 Waterview Pkwy, Richardson, TX 75080. Phone (214) 497-4000. FAX 214-497-4848.

Circle No. 731

Twin-channel fax card autoroutes messages

With two facsimile transceivers on a card, the TR112 twin-channel fax card doubles the number of channels you can accommodate on an IBM PC/AT or compatible. The 2-channel card comes configured with two loop-start interfaces, two direct-inward-dial (DID) interfaces, or one of each. The DID lines support a method by which faxes pass from the phone company's central office through your company's LAN server host software, via the TR112, to your own fax "mailbox."

The TR112 implements V.21, V.27, and V.29 of the CCITT Group 3 facsimile specifications on modulation techniques and the T.30 specification on fax message call sequence. In addition, both channels implement the encoding and decoding of ASCII data according to the T.4 specification. Graphics data is encoded on the host PC using software supplied by the application developer.

With optional onboard support for integrated fax and voice-response applications, you can program the TR112 to play back digitally recorded speech when it answers a call.
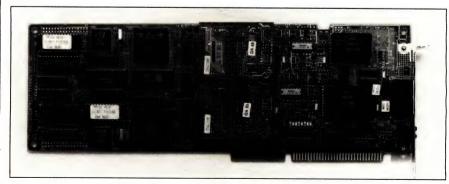
Other features of the TR112 include the capability to accept fax messages in ASCII form and convert them to facsimile format for transmission over the telephone network. You can program telephone interface parameters, such as signal level, Touch-Tone level, and ring detect frequency, allowing adaptation of the board to different international telephone requirements. Additionally, the unit offers the ability to combine fax files during transmission, so you can add letterhead and signature files to the body of your fax while you send it. And, with a 0-msec scan time, the TR112 can send data as fast as the receiving system can accept it.
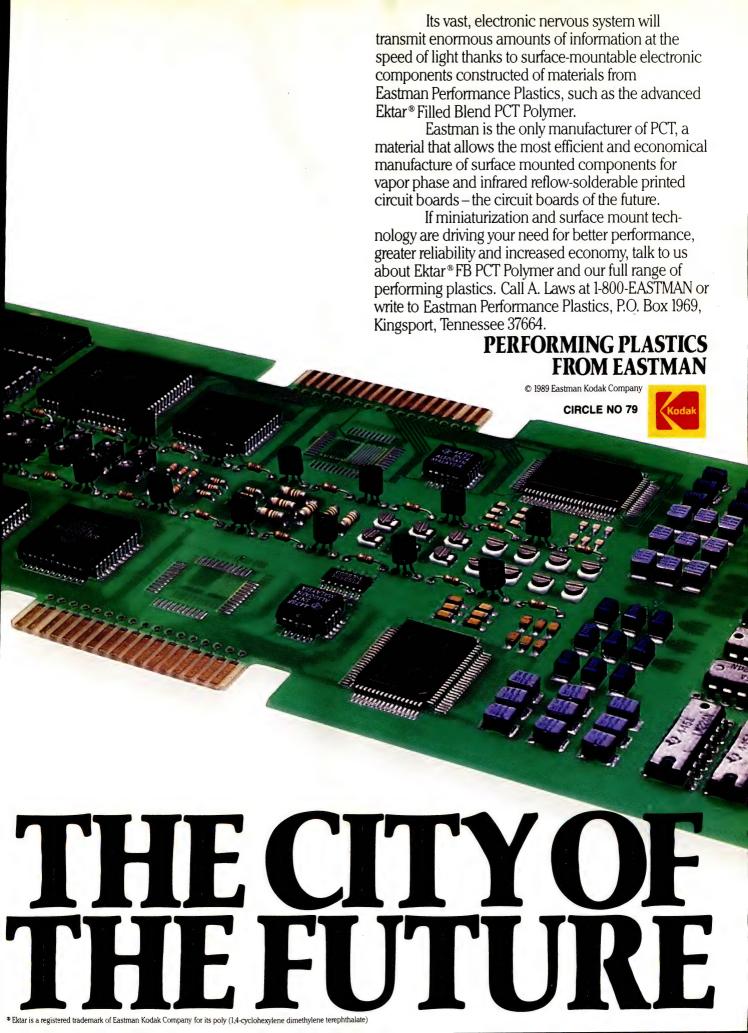
Device drivers for the TR112 are available for Unix V version 3.2, C DOS 6.2, MS-DOS, SCO Xenix 286, SCO Xenix 386, and Sun 386i. Two sets of diagnostic routines on the TR112 report the T.30 handshaking routines to the host PC for specific-call failure analysis, and a self-test-on-reset tests the RAM and ROM and performs some analog loopback tests. The board, in a configuration with either one or two DID interfaces, costs $2495; a board with two loop-start interfaces costs $1995.

—*Michael C Markowitz*

Brooktrout Technology Inc, 110 Cedar St, Wellesley Hills, MA 02181. Phone (617) 235-3026. FAX 617-235-0310. **Circle No. 734**

***This 2-channel,** PC-based fax card operates at 9600 bps and accepts 8.5-in.-wide images that can be as long as your storage device permits.*

Its vast, electronic nervous system will transmit enormous amounts of information at the speed of light thanks to surface-mountable electronic components constructed of materials from Eastman Performance Plastics, such as the advanced Ektar® Filled Blend PCT Polymer.

Eastman is the only manufacturer of PCT, a material that allows the most efficient and economical manufacture of surface mounted components for vapor phase and infrared reflow-solderable printed circuit boards – the circuit boards of the future.

If miniaturization and surface mount technology are driving your need for better performance, greater reliability and increased economy, talk to us about Ektar® FB PCT Polymer and our full range of performing plastics. Call A. Laws at 1-800-EASTMAN or write to Eastman Performance Plastics, P.O. Box 1969, Kingsport, Tennessee 37664.

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CIRCLE NO 79

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STD Bus 80C186-based CPU runs compiled code from ROM

The 80C186-based SB8186 STD Bus CPU card includes IBM PC-compatible peripheral ports, allowing it to run programs developed and compiled on a personal computer. For example, the 10-MHz 16-bit card executes code from ROM developed with popular compilers such as Microsoft C, Turbo Pascal, QuickBasic, and Turbo C. Hardware options for the card include an 80C187 math coprocessor and a battery-powered clock/calendar.

The SB8186 includes as much as 512k bytes of RAM and 384k bytes of ROM or EPROM. In addition, the board provides IBM PC-compatible COM1 and COM2 RS-232C ports, an LPT1 parallel port, and a KBD keyboard port. The COM1 port also offers RS-485 compatibility. An 8259A interrupt controller provides compatibility with IBM PC hardware interrupts. The card can perform both 8- and 16-bit transfers across the STD Bus.

An extended BIOS called RUN.EXE allows programs compiled on an IBM-compatible personal computer to be executed from ROM. You don't have to purchase MS-DOS or any other special operating systems, libraries, or emulators to run software developed on MS-DOS-based computers.

Unlike the many STD Bus cards available that offer complete compatibility with personal-computer software such as spreadsheets and word processors, the SB8186 simply allows you to do development work on your personal computer. Furthermore, the board costs only $550—much less than STD Bus cards that offer the capabilities of a complete personal computer. The price and capabilities make the board ideal for embedded applications.
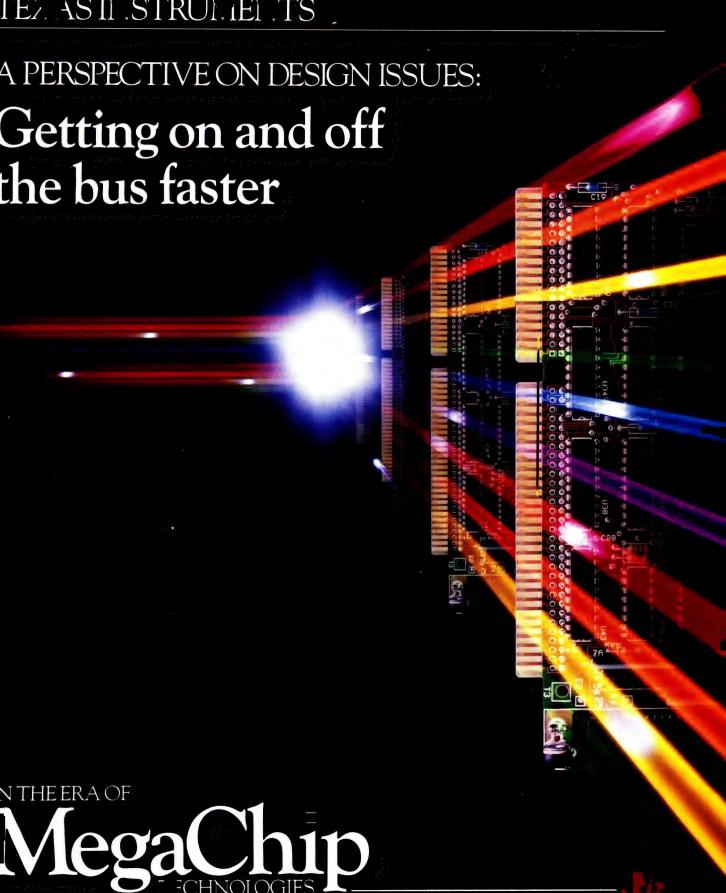
The company also offers the PC/XBug symbolic-source debugger for use with the SB8186. The debugger interacts with the board via a serial port and runs on any IBM-compatible personal computer. PC/XBug allows you to view registers in the 80C186 and 80C187, STD Bus memory, stack contents, source code, and disassembled code. Furthermore, the debugger supports breakpoints and single stepping at the source-code level. The PC/XBug costs $425.—*Maury Wright*

Micro/sys Inc, 1011 Grand Central Ave, Glendale, CA 91201. Phone (818) 244-4600. FAX 818-244-4246.
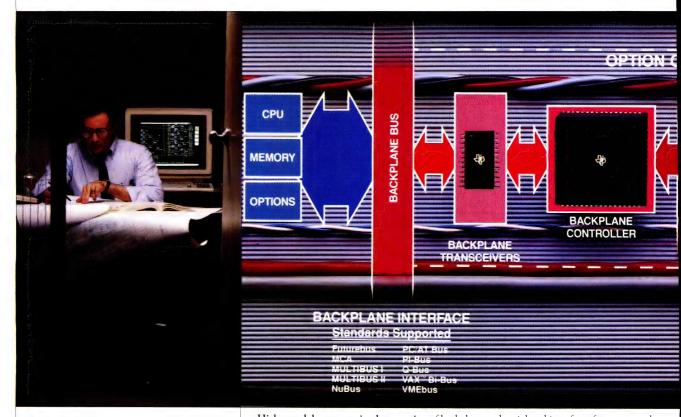
Circle No. 730

The 80C186-based STD Bus CPU card includes IBM PC-compatible serial, parallel, and keyboard ports. Using an extended BIOS called RUN.EXE, the board can also execute ROM-based code developed with popular IBM PC language compilers.

New bus interface ICs from TI can keep your total system up to speed.

You not only increase system throughput but cut power and conserve real estate at the same time.

OPTION

CPU

MEMORY

OPTIONS

BACKPLANE BUS

BACKPLANE CONTROLLER

BACKPLANE TRANSCEIVERS

BACKPLANE INTERFACE
Standards Supported

Futurebus	PC/AT Bus
MCA	PI-Bus
MULTIBUS I	Q-Bus
MULTIBUS II	VAX™ Bi-Bus
NuBus	VMEbus

High-speed, low-power implementation of backplane and peripheral interfaces for most popular standards is made possible by TI's comprehensive family of both digital and analog physical-layer

W hat use is a high-performance CPU if its processing power can't be delivered to the backplane and outward to the peripherals?

Typically, some system throughput is lost at the local bus interface, some at the backplane interface, and some at the peripheral bus interface.

To help you minimize such losses and maximize system throughput, Texas Instruments offers a series of innovative chips for (1) backplane interface and (2) peripheral bus interface, as well as (3) controllers to regulate data flow.

These devices support the major industry standards listed above so that you can achieve system compatibility regardless of the bus you are implementing.
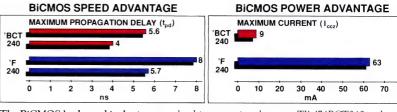
Superior backplane interface performance

To maximize system throughput, data must be able to get on and off the bus quickly. Therefore, the backplane bus transceivers must be capable of high speed and high drive.
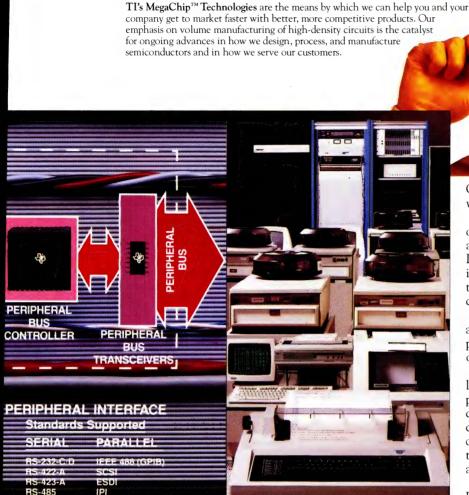
Our high-speed/low-power BiCMOS logic (SN54/74BCTXXX)

is specifically designed for bus interface applications.

As the name implies, TI BiCMOS merges low-power CMOS with high-speed bipolar, delivering switching speeds comparable to advanced bipolar devices. You also get the 48/64-mA

BiCMOS VERSUS ADVANCED BIPOLAR

BiCMOS SPEED ADVANTAGE

MAXIMUM PROPAGATION DELAY (t_{pd})

'BCT 240	5.6
	4
'F 240	8
	5.7

ns: 0 1 2 3 4 5 6 7 8

BiCMOS POWER ADVANTAGE

MAXIMUM CURRENT (I_{ccz})

'BCT 240	9
'F 240	63

mA: 0 10 20 30 40 50 60 70 80

The BiCMOS lead over bipolar is proven by this comparison between TI's '74BCT240 and a comparable advanced bipolar standard device. Typical propagation delay of TI's BiCMOS part is faster (*left*) while power dissipation is less (*right*).

TI's MegaChip™ Technologies are the means by which we can help you and your company get to market faster with better, more competitive products. Our emphasis on volume manufacturing of high-density circuits is the catalyst for ongoing advances in how we design, process, and manufacture semiconductors and in how we serve our customers.

PERIPHERAL BUS CONTROLLER

PERIPHERAL BUS TRANSCEIVERS

PERIPHERAL BUS

PERIPHERAL INTERFACE

Standards Supported

SERIAL	PARALLEL
RS-232-C/D	IEEE 488 (GPIB)
RS-422-A	SCSI
RS-423-A	ESDI
RS-485	IPI

ICs. To complete the implementation, TI offers a series of innovative standard and ASIC control devices. Use of TI's leadership bus interface devices can help shorten system design cycles.

drive current you need, and total system power savings can be as high as 25% (*see charts*).

There are more than 60 members in our BiCMOS family, including 8-, 9-, and 10-bit latches, buffers, drivers, and transceivers. The family is also available in military versions.

Our family of octal ECL translators (SN10KHT/100KTXXXX) delivers a low-power, high-speed translator solution with 48 mA of

drive capability on the TTL side.

Our high-speed Futurebus transceiver family (SN55/75ALS-05X) includes quad and octal devices compatible with Futurebus implementations of the IEEE 896.1 standard. With a drive capability of 100 mA, a 5-ns (typ) propagation delay, and a supply current of 65 mA (max), our SN75ALS053 has the best speed/power ratio of any Futurebus transceiver on the market today. ■

High-performance peripheral interfaces

Peripheral bus interface design decisions revolve around trade-offs between line length, data rate, and noise immunity.

Where data rates are low and

line lengths are short, as with the popular RS-232-C/D standard, the major concern is power savings. However, relatively high voltages (30 V) prevent the use of standard

CMOS devices. Your answer lies with TI's Linear BiCMOS family.

Included are low-power versions of industry-standard quad drivers and receivers (SN75C188/89). Driver/receiver combinations, ranging from single to quad combinations (SN75C1154), substantially cut package count.

This BiCMOS technology will also allow us to provide charge pump circuitry for single 5-V operation.

Where data rates are high and line lengths are long, as the newer peripherals demand, noise can become a major problem. It is overcome by the use of differential drive. Typically, the major application requirement is higher speeds at, ideally, lower power.

For example, disk drives using ESDI, IPI, or SCSI interfaces will benefit from TI's SN75ALS17X devices conforming to RS-422-A and/or RS-485 standards. These chips are fabricated using our unique IMPACT™ processing that delivers up to 50% greater speed compared to competing products with as much as a 30% power reduction.

IMPACT processing is also behind the unmatched speed of our SN75AS030 RS-422 dual driver/receiver. Typical propagation delays are only 6 ns. ■

No matter which of TI's innovative devices you choose to improve speed, cut power, and reduce real estate at the media interface, the complete bus interface requires another element — controllers. *For details on how TI is addressing your needs in this area, turn the page.*

High-performance controllers make system design easier.

While the majority of physical-layer devices—those used to implement backplane and peripheral interfaces—transmit data, your system design also requires a device to regulate the flow of that data through the bus interface. To do the job, TI offers a series of controllers that simplify and shorten your task while cutting chip count and improving overall system throughput.

Simplified NuBus design

TI has taken much of the work out of NuBus™ design by introducing the industry's first standard NuBus interface devices. They are the SN74ACT2440 NuBus Controller and the SN74BCT2420 NuBus Registered Transceiver.

A typical implementation, using two 16-bit transceivers and one 32-bit controller (*see below*), replaces as many as 45 discrete devices. Compared to a discrete approach, this solution uses 60% less board space and 90% less power.

Because the necessary logic is embedded within the controller, design cycle time is reduced significantly.

A low-power UART

There is now more need than ever for low-power RS-232 interfaces. Our TL16C450 Universal Asynchronous Receiver/Transceiver (UART), made with CMOS process technology, is an excellent choice for desktop applications and is especially suited for use in laptop/battery-powered units.

A flexible SCSI controller

Available soon, our SCSI controller (designed to conform to ANSI X3.131-1986 specifications) will deliver data rates of 3 Mbytes/s (asynchronous) and 5 Mbytes/s (synchronous).

Unique byte-stacking control logic will allow interface to 16-, 24-, and 32-bit buses. The TI controller will also provide powerful multiphase SCSI commands, including automatic handling of save-data pointer to minimize interrupts to the host processor. Dual 32-byte FIFOs will provide smooth, efficient buffering between processor and DMA ports.

Customized controllers, too

The NuBus and UART controllers are available as part of our ASIC standard-cell library.

In addition, TI offers TGC100 Gate Arrays and TSC500 Standard Cells as part of our ASIC family which allows you to build the precise chip functions you need. ∎

System complexity and the future

As systems become more and more complex, the need will emerge for combining the functionality of controllers and physical-layer devices on a single chip. To that end, TI is applying its acknowledged expertise in physical-layer devices to the design and development of such advanced control-level ICs.

System complexity also brings with it the need for simulation models to make design easier and faster. As a result, we already have simulation models available for more than 1,300 TI devices, including BiCMOS bus interface and ACL logic devices.
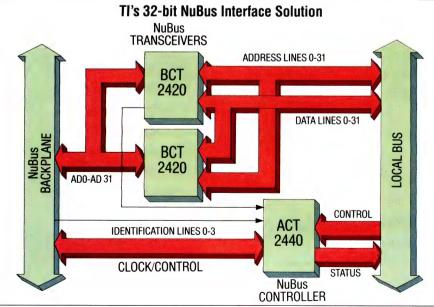
Another issue is the increasing difficulty and expense of testing boards in complex systems. Consequently, TI supports the JTAG/IEEE P1149.1 standard with the development of standard products and ASICs having on-chip test cells, as well as with development support software and device models on several leading workstations. ∎

TI's 32-bit NuBus Interface Solution

NuBus TRANSCEIVERS — BCT 2420 — BCT 2420 — ACT 2440 NuBus CONTROLLER — NuBus BACKPLANE — LOCAL BUS — ADDRESS LINES 0-31 — DATA LINES 0-31 — AD0-AD 31 — IDENTIFICATION LINES 0-3 — CLOCK/CONTROL — CONTROL — STATUS

Major space savings are realized by using one TI SN74ACT2440 controller and two SN74BCT2420 transceivers to complete a full 32-bit NuBus master/slave interface. As many as 45 discrete logic devices are replaced, realizing significant reductions in board space, power consumption, and design cycle time.

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TI military parts are currently serving in such diverse applications as avionics, computers, RADARs, missile guidance and controls, communications, SONARs, munitions, countermeasures, satellites, and fire control.

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ELASTOMERIC CONNECTORS

• •

meet SMT requirements

Impervious to corrosion, secured without solder, and suitable for use in high-density/high-frequency applications, elastomeric connectors offer you new interconnect options for circuit designs that conventional mechanical connectors can't accommodate. Featuring traces as fine as 2 mils and connector densities as great as 600/in., these silicone-rubber devices also allow zero-insertion force, offer vibration damping, and eliminate any need for through-hole plating.

At least one manufacturer argues that an elastomeric connector isn't a connector at all, but is more correctly referred to as a connector element, because an elastomeric device usually requires an additional rigid support or frame to immobilize its pliant form. Yet even this distinction is beginning to wane as elastomeric manufacturers improve their products. Elastomeric connectors are visibly different from their mechanical counterparts: initially, they were manufactured with alternating layers of pale, nonconductive silicone rubber and dark, carbon-impregnated conductive rubber, giving them a flexible, zebra-striped appearance. Fujipoly Inc (formerly Tecknit Inter-Connection Products) registered the Zebra trademark name for these connectors; since then, "Zebra connector" has practically become a generic term for all elastomeric connectors.

Today, manufacturers sandwich the conductive elements between either spongy or solid silicone-rubber strips to provide additional lateral strength and to eliminate the need for a supporting plastic frame. Indeed, certain manufacturers have broken completely with the traditional appearance of elastomeric connectors by wrapping gold-plated leads around spongy silicone-rubber cores. Shin-Etsu Polymer has even developed a 50-mm-wide elastomeric sheet called an MAF Connector that contains either gold or nickel boron conductive fibers.

One of silicone's most attractive qualities is that it's resistant to harsh environmental conditions; in fact, silicone rubber offers resilience without degradation under most environmental conditions. Silicone rubber tolerates exposure to ultraviolet radiation, oxygen, ozone, and humidity. It remains flexible at temperatures as low as $-55°C$, withstands continuous temperatures as high as 175°C, and can tolerate limited exposure to heat as great as 300°C. Unlike other rubber compounds, it won't become sticky or brittle with age.

Silicone rubber's electrical properties are equally stable. Regardless of temperature variations, the

Famous for connecting driver circuits to LCDs in cheap watches, elastomeric connectors became synonymous with disposable consumer electronics. Today, dense ICs, surface-mount technology (SMT) circuits, and robotic assembly techniques have created connection challenges that seem tailor-made for elastomeric solutions.

J D Mosley, *Regional Editor*

This Model 363 chip carrier and socket combination from Elastomeric Technologies lets a 76-pad ceramic LCC occupy only a 650-mil-square area on your pc board.

HARDWARE AND INTERCONNECT DEVICES

dielectric constant of silicone products remains 2.7, even for the gigahertz frequency range. Even if you were to saturate silicone with water, its resistivity would remain above $10^{12}\Omega$. Accordingly, silicone rubber is naturally resistant to metal migration within the dielectric material, so it helps prevent short circuits. However, unless you ensure that the conductive surfaces of the elastomeric element produce a gasproof seal once installed, the presence of moisture or corrosive gases will leave your connector susceptible to metal migration and compromise the integrity of the individual connections.

It's what's inside that counts

Because silicone rubber is such an excellent insulator, it must be combined with other materials to provide a conductive path. The first elastomeric conductor elements were created by combining the silicone rubber with carbon, mainly due to the previously described migration problems encountered with metal-filled conductors. Featuring contact resistances in excess of 500Ω, carbon-impregnated, conductive rubber connectors are high-impedance devices suitable for low-current applications, particularly those featuring LCDs.

The elastomer substrate provides added benefits of shock and vibration protection for the display when the glass of an LCD is placed directly on such carbon-filled, rubber-based connectors, as illustrated in **Fig 1**. In addition, the gasket-like seal, produced by sandwiching the connector between an LCD and a pc board, also provides a highly effective environmental seal.

The cost benefits from using these original connectors decreased dramatically when applications required plastic support structures for connectors longer than 1 in.; therefore, these devices were recommended primarily for use with LCDs measuring less than 1-in. long. Peripheral support frames for these elastomeric elements not only keep the flexible conductor in place, but also ensure accurate positioning and help prevent the circuit board from bowing or deflecting away from the conductor. Uniform pressure across the length of the elastomeric element is critical to the electrical integrity of your circuit. In addition, any variations or irregularities along the surface of the substrates being connected will also have a negative effect on contact reliability.

You can now purchase self-supporting elastomeric connectors that eliminate the need for plastic retainers with spongy or solid silicone-rubber strips. However, a length of 2.5 in. currently seems to be the practical limit for elastomeric devices used in typical packaging designs. Beyond the 2.5-in. limit, the deflection forces created by the connector can cause your pc board to bow. Of course, you can always position a series of connectors end to end to produce longer connections, and you can add stiffeners

#2-TYPE 25 SCREW (2) 5/16 LONG

CLEAR BEZEL

MASK

LCD

ZEBRA STRIP

CONNECTOR FRAME

PC BOARD
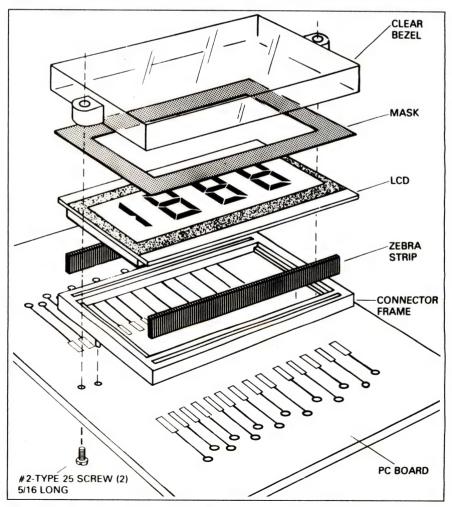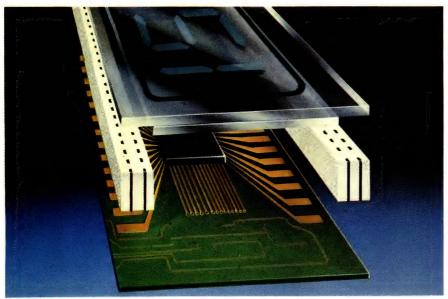
Fig 1—Well suited for the high-impedance/low-current requirements of LCDs, Fujipoly's Zebra strips provide the additional benefits of shock and vibration damping for the display.

Featuring a double row of embedded metal filaments that spring to prevent damage during compression, Shin-Etsu's G Connector series of low-resistance contacts uses a pair of sponge-rubber support strips that protect the electrodes from harsh environments.

(plastic frames) to the back side of the contact area to prevent bowing.

You should note, however, that your particular application may still require you to use peripheral support frames. This would certainly be the case if you're using 2-sided circuit boards that aren't rigid enough to provide uniform compression on the connector, or if your packaging constraints necessitate the precise standoff spacing offered by a support frame. A plastic frame

With their conductive elements on top of the elastomer rather than embedded in the silicone rubber, Fujipoly's Series 8000 connectors provide low-resistance board-to-board connections with minimal compression force.

can also serve multiple purposes, as illustrated by Elastomeric Technologies' Model 363 Land Grid Array socket, which doubles as a chip carrier.
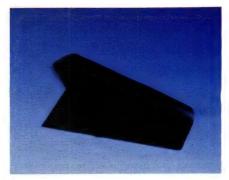
Obviously, such applications involving board-to-chip and board-to-board connections also require low-impedance connector elements. As pc-board signals reach gigahertz speeds, carbon-filled elastomers, with their high contact resistance, simply aren't a reasonable alternative to mechanical connectors. However, SMT and shrinking board traces are naturally attuned to the solderless connectivity and dense contact spacing of elastomeric connectors. So the elastomeric manufacturers once again proceeded to fill silicone rubber with metals such as gold, silver, and copper.

Metals meet the need for speed

The resulting metal-filled elastomers have contact resistances as low as 0.02Ω and current-carrying capacities as high as 3A. Yet contact densities remain as high as 250

lines/in. Even if your circuit's traces aren't that dense, the highly concentrated elastomeric contacts can boost your system's reliability by providing redundant contacts for each trace or pad you're connecting. In addition, redundant contacts greatly simplify positioning requirements for robotic assembly, in contrast to the precision that a robot must maintain while aligning devices that necessitate one-to-one connectivity.

The Model 363 is a prime example of this new breed of elastomeric connector. The contacts incorporate silver-impregnated, silicone-rubber elements. A stainless-steel snap lid holds the IC in place, compresses the elastomeric elements, and provides a gastight seal. This socket lets you interface a 76-pad ceramic LCC to a 650-mil-square area on a pc board. This connector occupies one-third the area of a conventional chip carrier, and the solderless pad-to-contact connections minimize signal degradation and accommodate high switching speeds. Furthermore, the 363 is a surface-mount device that requires no plated throughholes. Although the device was developed in conjunction with Bell Communications Research, the 363 is now a $10 standard product
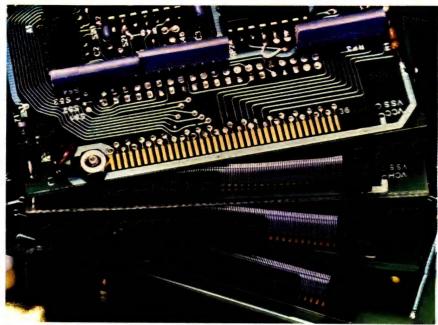
Designed for use as a connector for leadless LSI chips, this Shin-Etsu connector features gold-plated fibers protruding several microns above a high-density, nonconductive sheet of silicone rubber.

(in OEM quantities) for Elastomeric Technologies.

If you have a low-compression-force, low-resistance board-to-board application, you may want to consider Fujipoly's Series 8000 connectors. The connector elements are parallel Cu/Ni/Au-plated conductors bonded to a 1-mil polymide film, which is then vulcanized onto a resilient elastomer core. Typical contact resistance for Series 8000 connectors is less than 15 mΩ compared with the 100-mΩ typical contact resistance of chemically etched conductors. The Series 8000 connectors cost less than $0.02/contact.

Shin-Etsu's G Connector similarly provides a low-resistance connection between boards or boards and ICs. However, these connectors have two rows of metal filaments embedded in solid silicone and then sandwiched between two layers of spongy silicone rubber. The double row of electrodes pro-

Because they provide redundant conductor points for each pc-board contact, you can sandwich Fujipoly's Zebra connectors between parallel pc boards to simplify the interconnection task.

vides redundant contact; to avoid damage, each metal filament is designed to spring when compressed.

Shin-Etsu also manufactures the sheet-like MAF Connector. Suitable for use as a high-current

Caution: You're not simply buying a connector

If you have no prior experience using silicone-rubber devices, make sure you feel comfortable dealing with the elastomeric manufacturer that you select. You'll have to work closely with that company to select or design a connector that meets your needs.

Silicone-rubber connectors are available in a vast assortment of shapes and sizes, and the differences directly affect the contact resistance of a connector. The formulas for determining resistance values vary, but all of the formulas are a function of either two or three of the connector's dimensions as well as a constant based upon the composition of the conductive elements.

Likewise, the clamping force required to maintain electrical integrity is a function of the connector's dimensions, the percentage of deflection, and a constant associated with the elasticity of the conductive material. An additional wild card comes into play as the spring force of the clamped elastomeric diminishes over time—a transformation called stress re-

laxation. As long as the clamping force is properly determined, stress relaxation shouldn't affect the long-term operation of your circuit.

Even the dimensions of the elastomeric element itself are problematic. As long as the height of the element is less than or equal to 3.5 times its width, you'll probably be able to use a self-supporting connector and save the expense of a peripheral plastic retainer.

Also, unless the conductive surfaces of a metal-filled elastomeric element compress to produce a gasproof seal, the connector will be vulnerable to metal migration in harsh environments. Such migration ultimately results in short circuits and compromises the integrity of your circuit. Before making your final selection, check the connector's temperature and humidity specifications, and make sure they meet the environmental requirements of your application.

Uniform pressure across the length of the elastomeric element is critical to the electrical integrity of your circuit.

From simple strip connections to intricate, fine-pitch SMT packaging, the assortment of connectors from Elastomeric Technologies illustrates the wide range of connectors available for meeting high-density interconnection needs.

leadless IC connector, the MAF Connector comes in seven thicknesses, ranging from 8 to 32 mils, and you can order custom shapes and sizes to meet your design specifications. Both the G and the MAF Connectors cost less than $1/in.

These unique connector elements may not provide the total connector solution for your application; design constraints may require you to use both elastomeric and conventional connectors to achieve the best price/performance ratio. In addition, you may have to work in concert with an elastomeric manufac-

turer to create an unusual retainer, socket, or frame that will meet your production and packaging needs. If the manufacturer can supply you with nothing more than pliant elastomer elements, you may be buying less than the complete connector that your system requires. **EDN**

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3. Mitsuhashi, M and Y N Uritani, *Low-Resistance Elastomeric Interconnectors*, Shin-Etsu Polymer report.
4. Sharpe, William P, "Elastomeric connectors target fine lines and high density,"*Electronic Packaging & Production*, August 1989, pg 54.
5. Uritani, Y N, *Elastomeric Interconnectors for the US Market*, Shin-Etsu Polymer report.

Article Interest Quotient
(Circle One)
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For more information . . .

For more information on the elastomeric connectors discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Conductive Rubber Technology Inc
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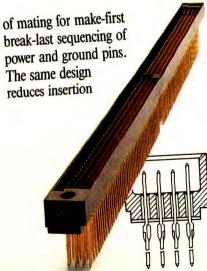
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Two levels of sequenced mating allo "hot" connect/disconnect. Complia pin option for solderless pcb insertio

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Hardware and Interconnect Devices

Ruggedized cases contain a mounted internal chassis

Each case in the Val-An 900 Series features an internal chassis that can be either hard mounted or shock mounted to its main body. An interlocking feature lets you stack cases in the field in a stable manner. The cases come with either a removable front and rear cover or a removable front cover only, and the covers latch with T-type quarter-turn handles. The cases also have recessed handles, waterproof construction with a pressure-relief valve, and optional EMI shielding. These cases are available in 12 standard configurations with panel heights from 5.25 to 28 in. and depths ranging from 12 to 36 in. For additional storage space, you can also opt for inner lids for the front or rear panels. The units meet the applicable requirements of the MIL-STD-108 and MIL-T-28800 standards. Each case costs $525.

Zero West Div, 777 Front St, Burbank, CA 91503. Phone (818) *846-4191. FAX 818-842-1876.*

Circle No. 671

Stepper motors offer 30% improvement in efficiency

The Accustep family of permanent-magnet stepper motors provide as much as 30% improvement in efficiency and heat dissipation over the company's previous models. The motors feature encapsulation of the stator in a thermal plastic resin. Advanced manufacturing techniques permit the air gap between the stator and rotor to be reduced to 70 µm. The stator, bobbin, and end plate are molded into one piece. Standard models have pullout torques ranging from 34 to 1100 g•cm for a driving frequency of 100 pps. The models come with drive voltages of 5, 12, and 24V and require either unipolar- or bipolar-drive circuitry. The number of steps per rotation varies from 20 to 100. Prices range from $4 to $5 in volume quantities. Delivery is 14 to 16 weeks ARO.
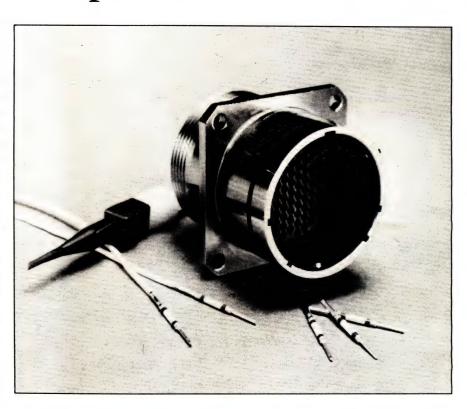
NMB Technologies Inc, 9730 Independence Ave, Chatsworth, CA 91311. Phone (818) 341-3355. FAX 818-341-8207. TLX 651340.

Circle No. 672

Connectors combine crimp connection with EMI protection

The vendor's Programmable EMI/RFI connectors combine the versatility of crimp connection with EMI/RFI protection. The connectors can be used as filter connectors or as transient protection devices. The units are available with metal-oxide varistors or diodes, which you can use with an EMI filter for each contact or combine for any individual insert pattern. The metal-oxide varistors or diodes offer transient protection for voltages ranging from 5 to 240V dc. You simply insert and remove the crimp-style EMI contacts from the rear of the connector. You can use a standard M81969 insertion tool to replace a damaged contact. To crimp the EMI/RFI contacts, you can use an M22520 crimp frame with the company's 11-12147-XX positioner assembly. The connectors are available in both pins and sockets in sizes 16, 20, and 22. $100 to $300. Delivery is 16 to 18 weeks ARO.

Amphenol Corp, Bendix Connector Operations, 40-60 Delaware Ave, Sidney, NY 13838. Phone (607) 563-5301. Circle No. 673
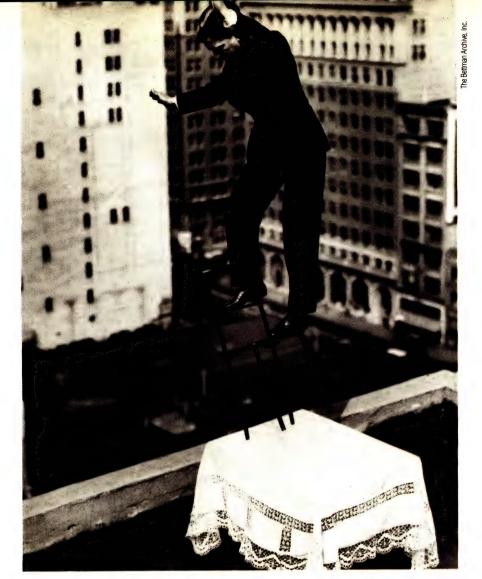
Self-aligning LED mount has an internal tapered barrier

The T-1-3/4 LED spacer is a self-aligning mount for T-1-3/4 LEDs. It features an internal tapered barrier that simplifies LED mounting. The internal configuration guides the leads when mounting the LED so that crimping and shorting are impossible. The technique ensures a positive 0.10-in. center mounting.

The bosses, which connect to a pc board, serve the dual purpose of providing heat dissipation and facilitating soldering cleanup. The unit is molded from 6/6 natural nylon and meets 94V-2 UL requirements. Standard units have 0.197-in. outside diameters and range in length from 0.12 to 0.90 in. Special

sizes are available in production quantities. Prices range from $3 to $9 (100), depending on the quantity.

Keystone Electronics Corp, 31-07 20th Rd, Astoria, NY 11105. Phone (718) 956-8900. FAX 718-956-9040. Circle No. 674

Hardware and Interconnect Devices

DIN 41612 coding strips prevent wrong-slot card insertion

A series of coding strips are available for DIN 41612 connectors to prevent the insertion of a card into the wrong slot of a chassis. The strips are available for connector types B, C, D, E, H11, M, Q, and R. You can screw or rivet the strips to the connector without drilling holes. To code the units, break off teeth on opposite sides of the strip. Use coding strip M on the daughter-card side and mate it to coding strip F, FL, or UE on the backplane side. Depending on how you code eight of the 16 possible coding teeth, you can generate as many as 12,870 insertion codes. You can mount the strips at a pitch of 15.24 mm for all the connector types except type E, which requires a pitch of 20.32 mm. The strips are durable enough to be inserted at an angle and to withstand an insertion force as great as 250 newtons in the mating direction. $0.50 in volume quantities.

ERNI Components Inc, 520 Southlake Blvd, Richmond, VA 23236. Phone (804) 794-6367. FAX 804-379-2109. Circle No. 675

Ribbon connectors have 0.050-in. centerline spacing

These I/O D-subminiature and ribbon connectors permit termination of 0.50-in. centerline spacing flat cable. The devices are available as pc-board connectors or as insulation-displacement-type connectors used in computer interfaces. You can use them in RS-232C or RS-449 applications; they come in a variety of shell sizes and mounting styles with either straight or right-angle pins. The D-subminiature connectors come with 9, 15, 25, and 37 male and female contacts. Grounding detents in the male shell suppress EMI and RFI leakages. The body consists of black, glass-filled polyester with plated metal shells. The ribbon connectors have either 36 or 50 contacts and feature bail latches. Both connectors have phosphor bronze contacts with 15 or 30 micro-inches of gold over nickel plating. They also have either threaded 4-40 UNC or through-hole mounts. Prices start at $1.08 each.

Panduit Corp, 17301 Ridgeland Ave, Tinley Park, IL 60477. Phone (800) 777-3300. FAX 312-532-1811. Circle No. 676

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The 88000's BCS allows for a scope and diversity of products that isn't possible in the proprietary (MIPS®-based) or clone (Intel® or SPARC™-based) environments. In fact, the 88000's BCS was

The 88000 RISC microprocessor is the power behind an impressive range of hardware: PC add-in boards, personal workstations, graphics workstations, multiuser business computers, and even multiprocessor supercomputers.

defined precisely so as not to put limitations on hardware development.

What's more, the 88000 is the only RISC architecture with a set of test suites for both hardware and software—providing "plug and play" software interoperability.

BUT THERE ARE MANY STANDARD BEARERS.

The hardware manufacturers whose logos you see here are all part of the 88open—a consortium of more than 50 companies making the 88000 the world's standard RISC architecture.

PANDUIT® *LAT-CON*™ Connector System
Lateral is Logical

Lateral entry *increases your output up to 400%*, by eliminating rework and scrap *without* increasing labor costs.

That's why it's logical to terminate .050″ flat cable with LAT-CON connectors. In this unique system, the cover and socket are supplied joined on one side with the opposite side open. This permits *fast and accurate* lateral entry and termination of the flat cable when used with Panduit's unique, inexpensive tooling.

And the patented design makes it logical to use the *same connector* for both end and daisychain terminations, allowing you to cut your inventory costs and boost your productivity.

Panduit's logical LAT-CON system gives you all these benefits:
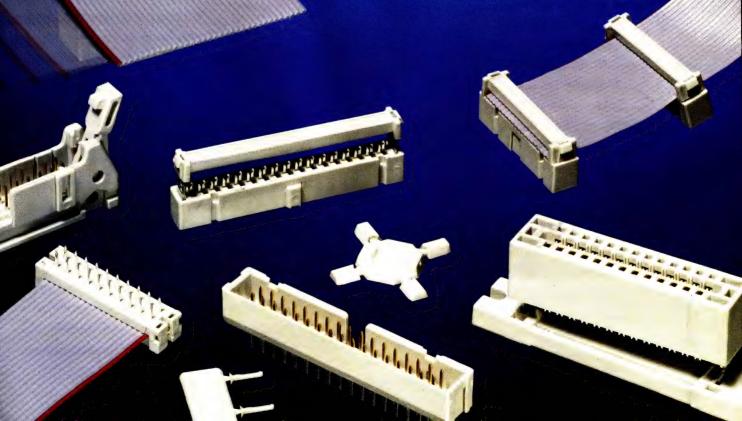
- Broad line of .050″ products, including sockets, card edge and transition connectors; three styles of headers.
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CIRCLE NO 90

Hardware and Interconnect Devices
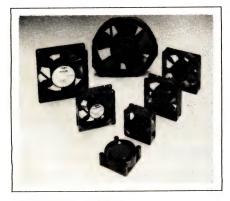
Clip Adapters

The Adapt-A-Clip line of adapters clip onto µPs soldered to a pc board. The adapters allow you to connect an emulator pod to the target processor for debugging. Clipping onto the outside of a plastic leaded-chip carrier (PLCC), the adapters provide pin-grid-array (PGA), DIP, or LCC-type pod connections. For example, an Adapt-A-Clip can adapt a 68-pin PLCC device to a standard 68-pin PGA socket. The vendor can manufacture device-specific clips for any of the popular soldered PLCC devices. From $185.

Emulation Technology, 2368B Walsh Ave, Bldg D, Santa Clara, CA 95051. Phone (408) 982-0660.
Circle No. 425
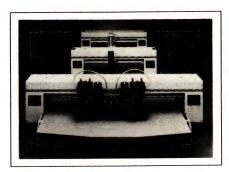
Axial-Flow Fans

The NL series is a variety of Boxer axial-flow fans containing 12 or 24V dc motors. The fans feature a ball-bearing construction and an autorestart feature. A locked rotor alarm or speed sensor is available as an option. Models come in 2.4-,

3.1-, 3.6-, and 4.7-in. sizes to deliver a 12- to 51-cfm air flow. The fan blades are made of a soft plastic material that shifts the noise spectrum from annoying high frequencies to more acceptable lower frequencies. Noise ranges from 20 to 38 dBA are available. $6 to $7 (OEM qty). Delivery, 12 weeks ARO.

NMB Technologies Inc, 9730 Independence Ave, Chatsworth, CA 91311. Phone (818) 341-3355. FAX 818-341-8207. TWX 910-494-1232.
Circle No. 426

Prototyping Machine

The 2222 machine turns out prototype circuit boards for limited production runs. The unit permits you to make board changes without having to wait for the machine to come back from a fabrication house. A single-head machine can make boards with sizes ranging to 22 × 22 in. A dual-head machine can simultaneously make two boards measuring 10 × 22 in. each. The machine can construct 4-mil lines that are spaced by 8 mils at a speed of 1.4 in./sec. In addition, the unit can drill holes measuring 0.6 to 3 mm at 20,000 rpm. Single-head machine without options, $12,000; dual-head machine without options, $14,000.

Instant Board Circuits, 20A Pamaron Way, Novato, CA 94949. Phone (415) 883-2626.
Circle No. 427

Heat Sinks For DC/DC Converters

Two models of heat sinks are available for cooling 2.4 × 4.6-in. dc/dc

converters. Model 410011 has lengthwise fins and a thermal resistance of 3.5°C/W under natural air convection. This model has a thermal resistance under forced-air convection ranges from 0.6°C/W at 1000 linear ft/minute to 2.0°C/W at 100 linear ft/minute. Model 410111 has crosswise fins and a thermal resistance of 3.0°C/W under natural convection. This model has a thermal resistance under forced-air convection that ranges from 0.5°C/W at 1000 linear ft/minute to 1.5°C/W at 100 linear ft/minute. The heat sinks are made from an aluminum alloy and come with a gold chromate or black anodize finish. Model 410011, $4.21; Model 410111, $4.23 (1000). Delivery, stock to six weeks.
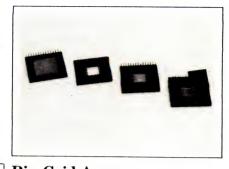
Aavid Engineering Inc, Box 400, Laconia NH 03247. Phone (603) 528-3400. FAX 603-528-1478. TWX 510-298-1127. **Circle No. 428**

Modem Abort Timer

Model 328 modem abort timer connects between modem and computer ports. It monitors the communications interchange and disconnects the hookup when it detects zero data flow. The timer features a switch-selectable 1 through 16-minute timed interval from initial dial-up to modem abort. It determines whether there has been a transmit data (TD) or a receive data

(RD) signal during the timed interval. If it detects no TD or RD signal during the timed interval, the 328 drives the data carrier detect (DCD) signal low for 5 sec. In turn, the host releases the line, freeing the modem to receive new incoming calls. The unit supports synchronous and asynchronous communications and is transparent to full-duplex data and protocol signals. The module comes with male and female DB25 connectors to ease termination procedures. $87.

Telebyte Technology Inc, 270 E Pulaski Rd, Greenlawn, NY 11740. Phone (516) 423-3232. FAX 516-385-8184. Circle No. 429

DOT MATRIX LCD's

- Wide viewing angle
- Wide operating temperature
- High reliability for a wide range of applications
- Large character (5.44 mm x 9.3 mm) available

Super twisted (better contrast & viewing) option available on all models

Char. x Line	Outside Dim. (w x h x d)
16 x 1	80 x 36 x 9.50 (mm)
16 x 2	80 x 36 x 9.50
16 x 2	160 x 52 x 12.00 (large char.)
20 x 1	116 x 37 x 9.50
20 x 2	116 x 37 x 9.50
20 x 4	98 x 60 x 12
24 x 1	118 x 36 x 12
24 x 2	118 x 36 x 12
40 x 1	182 x 33.5 x 12
40 x 2	187 x 40 x 11.00
40 x 4	195 x 70 x 11.00

Row x Column	Outside Dim. (w x h x d)
240 x 64	180 x 75 x 12.00
256 x 64	180 x 70 x 12.00
480 x 64	298 x 80 x 11.00
640 x 200	270 x 150 x 13.00
640 x 400	270 x 198 x 13.5

All models with Electro Luminescence Back Light option.

Write for ''Liquid Crystal Displays'' brochure.

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Phone: (312) 981-5655
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TWX: 910-687-2847

CIRCLE NO 91

Pin-Grid-Array Packages With Heat Sinks

A series of plastic pin-grid-array (PGA) packages are available with integral heat sinks. The plastic PGA packages offer thermal properties equal to, and in some cases exceeding, conventional ceramic PGA packages. The packages can achieve a thermal dissipation of 5°C/W. The design permits the package to have a variety of heat sinks that provide a solid-metal thermal interface between the chip surface and the outside of the package body. The plastic packages are pin compatible with standard ceramic packages, and *custom* packages with more than 300 pins are available. The package body is made from Ryton polyphenylene sulfide, and the pin material is phosphorous bronze with a nickel gold plating. $0.03 to $0.05/pin. Delivery, six to eight weeks ARO.

Interconnect Systems Inc, Box 1089, Simi Valley, CA 93065. Phone (805) 581-5626. FAX 805-581-5032. Circle No. 430

Terminal Blocks

The ELF Series pluggable terminal-block system consists of plugs and headers and provides smooth separation of mated plugs and head-

ers. Once mated, you can separate the plugs and headers by slipping a screwdriver into a U-shaped slot on the face of the header and turning it 90°. Wire terminations are accomplished with a moving vise clamp. Pin and socket housings let you terminate wires while the connector is in either the plugged or unplugged position. The terminal blocks are available in two to 24 positions that have 0.200- or 0.197-in. centers. You can use the blocks with wires as large as #12 AWG. 10-position mated pair, $5 (1000).

Precision Connector Designs Inc, 2 Technology Dr, Peabody, MA 01960. Phone (508) 532-8800. FAX 508-532-6800. Circle No. 431

Tower Enclosures
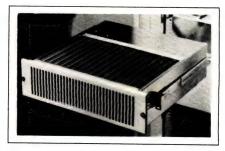
A selection of tower enclosures are available for portable VMEbus systems. The enclosures come in 3U,

4U, 5U, and 6U widths (1U = 1.75 in.). The towers can accommodate as many as 12 boards and can be used as desktop enclosures. The 3U-wide enclosures can accept as many as five boards in single, double, and triple heights. The 4U units house as many as seven boards, and the 6U units can contain as many as 12 boards. The mechanical dimensions conform to the DIN 41494 part 5 standard. The enclosures are 17 in. high and come completely wired and tested with

J1 and J2 backplanes as well as power supplies and fans. 5-slot tower, $300.

Elma Electronic Inc, 41440 Christy St, Fremont, CA 94538. Phone (415) 656-3400. FAX 415-656-3783. Circle No. 432

Heat Exchanger

This air-to-air heat exchanger is available for mounting in 19-in. racks. The unit is 133 mm (3U) high and is capable of a thermal output of 25W/°C when comparing the inside temperature with the outside

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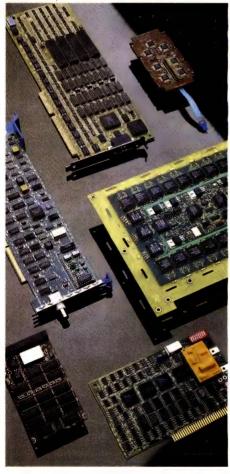
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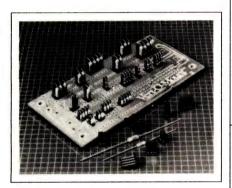
Hardware

temperature. You can install card frames above and below the unit. Separate circuits for internal and external air prevent dust and pollution in the outside air from adversely affecting the equipment. The exchanger comes with mounting slides, a front panel, and filters; it can operate from either 100/115V or 220/240V power outlets. $500 to $900, depending on quantity. Delivery, six weeks ARO.

Bicc-Vero Electronics Inc, 1000 Sherman Ave, Hamden, Ct 06514. Phone (203) 288-8001. FAX 203-287-0062. Circle No. 433
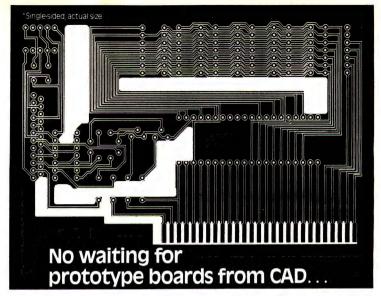
Vertical Component Mounts

Vert-O-Mounts are vertical component mounts for DO-7, DO-34, and DO-35 diodes and ⅛, ¼, and ½W resistors. The series has 12 mounts with heights of 0.312, 0.437, or 0.562 in. They meet MIL-M-38527/11 requirements as well as the vertical-mounting requirements of WS-653E. They are molded of black thermoplastic polyester per MIL-P-46161, grade B, class 30 standard. The material is UL rated for continuous operation at 130°C and 94V-0 UL requirements. The units are available in single, double, triple, and quadruple station styles. 2Standoffs enable the user to clean and inspect the mounts thoroughly. $37.50/ million (10M qty).

Bivar Inc, 4 Thomas, Irvine, CA 92718. Phone (714) 951-8808. FAX 714-951-3974. TLX 852348.
Circle No. 434

Closed-Cell LCD Connector

The LG251 connector can mount an LCD to a pc board. The unit features two rows of conducting elements, which are centered on a closed-cell silicone sponge. Designed to work where compression could cause the connector to bow, the double rows ensure contact between the LCD and the pc board. Electrical properties include a dielectric strength of 25 kV/mm; volume resistivity of 5Ω-cm; a temperature range of -55 to $+450°F$, and insulation resistance of $10^{12}\Omega$ at 500V dc. The standard pitch for the pins is 0.01 in. with options for 0.006- and 0.004-in. pitches. The maximum length is 5.5 in., and the minimum height is .051 in. Widths range from 0.050 in. to 0.157 in. $0.29.

Conductive Rubber Technology Inc, 201 N Salsipuedes St, Suite 100, Santa Barbara, CA 93103. Phone (805) 965-6511. FAX 805-963-2652. TLX 658305.
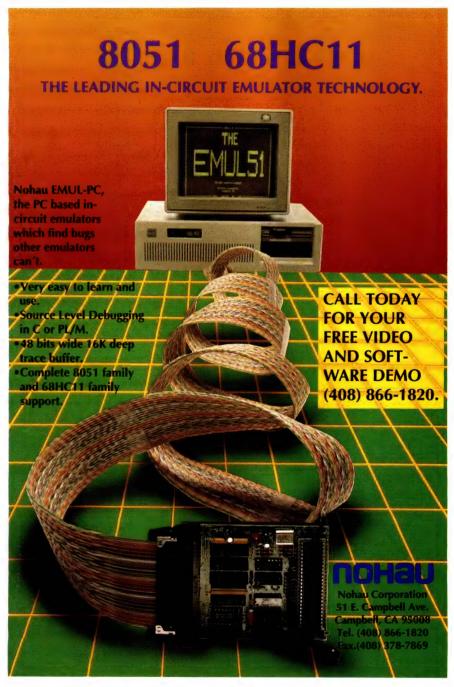
Circle No. 435
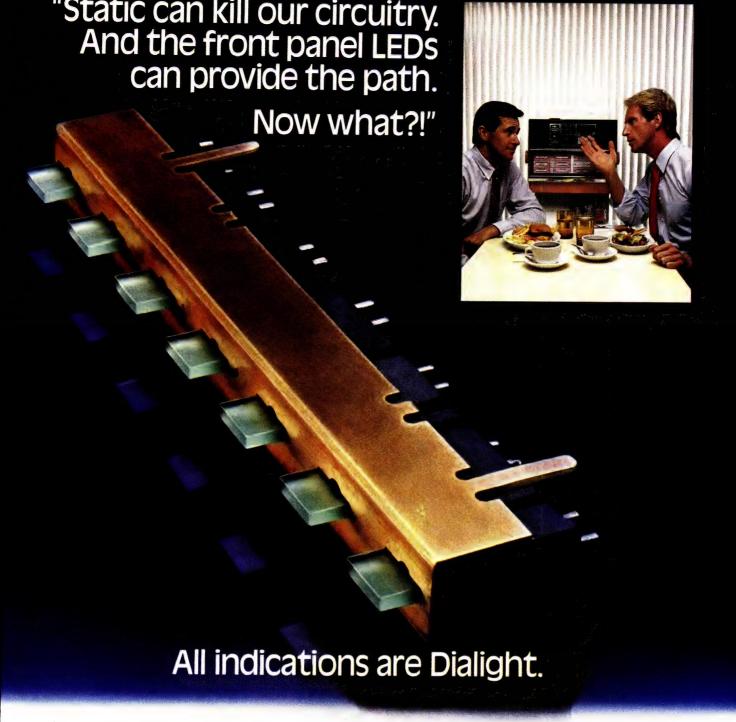
Labor- And Space-Saving Gang Jacks

The GA series and the GP series are gang jacks in right-angle and perpendicular styles, respectively. The jacks are available in dual, triple, quadruple, quintuple, and octagonal configurations. You can specify six position openings having as many as six contacts. Metal locking brackets permit quick insertion into a pc board. The contact material is phosphor bronze with 0.000015-in. gold plating on the contact area. The contacts are rated for 1.5A. Dual jack, $1.20; octagonal model, $5.40 (OEM qty). Delivery, six to eight weeks ARO.

Kycon Cable & Connector Inc, 1772 Little Orchard St, San Jose, CA 95125. Phone (408) 295-1110. FAX 408-295-8054. Circle No. 436

Bendix® Connectors — tomorrow's technology today.

Programmable – Removable filter or transient protection for maximum flexibility in circuit design.

The Bendix® transient protection system is the weight, space and cost saving way to protect sensitive circuitry from interference or destruction by energy transients.

To meet these threats the Bendix® system can package filters, diodes or metal oxide varistors (MOV) individually or in combination within a connector that is intermateable and intermountable with MIL-SPEC connectors. This same protection is now available with **programmable – removable** EMI/EMP contacts.

Programmability with rear insertable, rear removable contacts enhances user flexibility, allowing unique mixes of filters, ground contacts, feed-thrus and power contacts.

System maintenance is simplified using Bendix® front repairable connectors. The need to remove flex print or printed circuit boards for repair purposes is eliminated, as is the need to enter a sealed box.

Programmable or repairable EMI connectors are available with single capacitors or Pi filter arrangements in the MF, VHF, and UHF frequencies. EMP repairable protection is available for sensitive circuits ranging in voltage from 5V to 200V, and with unipolar or bipolar characteristics. Both pin and socket contacts are available in sizes 16, 20 and 22.

For more information on the Bendix® programmable – removable transient protection system
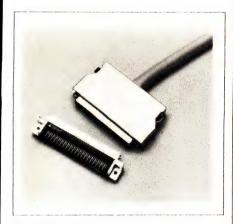
Call (607) 563-5301 or (607) 563-5309

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CIRCLE NO 98

Hardware

50-Mil I/O Connectors

The RN PAK-50 I/O connector system is a series of dense connectors with 50-mil spacing between contacts. A selection of 20 to 100 positions is available. You can choose a right-angle exit for connectors having 20 and 50 positions. The connectors operate with #28 AWG discrete wire cable and are fully EMI shielded. A solid metal cover has an integrated snap-on locking mechanism that makes mounting hardware unnecessary. $0.20/contact (1000). Delivery, stock to eight weeks ARO.

Robinson Nugent Inc, Box 1208, New Albany, IN 47150. Phone (812) 945-0211. FAX 812-945-0804. TWX 810-540-4082. Circle No. 437
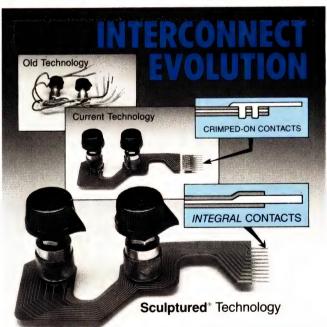
Battery Clips

These surface-mount printed-circuit battery clips are available for A-and AA-size batteries. The clips operate with batteries designed for computer-circuit protection and general-usage types made of alkaline, lithium, mercury, zinc, and nickel cadmium. Incorporated in the shock- and vibration-resistant clips is a snap-in feature that ensures

firm positioning during wave soldering. The clips have diameters ranging from 0.531 to 0.669 in. and are manufactured with 0.015-in. nickel-plated spring steel. The solder tabs measure 1.5×0.062 in. $0.04 to $0.11.

Keystone Electronics Corp, 31-07 20th Rd, Astoria, NY 11105. Phone (718) 956-8900. FAX 718-956-9040. TLX 353700.

Circle No. 438

Power Entry Modules

The C Series consists of power modules with an IEC (integrated electronic component) connector and a double IEC fuse holder (20 mm). The series adapts to either 100/120V ac or 200/240V ac input voltage by reversing the fuse holder. The current rating is 6A at 250V ac and 10A at 115V ac. The lifetime measures 10,000 cycles, and the
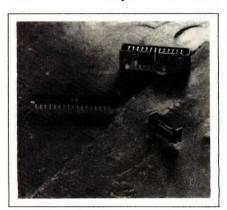
maximum in-rush current is 51A. The family has a high potential rating of 2250V dc from line to ground and 1450V dc from line to line for a period of 1 minute. The series operates at 50- to 60-Hz line frequencies, and all models are UL, CSA, and VDE approved. $0.50 to $6.

Delta Products Corp, 3823 Spinnaker Ct, Fremont, CA 94538. Phone (415) 770-1660. FAX 415-770-0122. TLX 4992342.

Circle No. 439

Low-Profile Connectors

The FCN790 series of connectors is designed for use with add-in cards for laptop computers and as an interconnection in disk drives. The low-profile connectors have contacts spaced 0.100 in. within a row and 0.050 in. from row to row. The contacts are staggered to maximize the density of the connector. In additon, the connector can mate to standard 0.050-in.-pitch flat-ribbon

cable. The units are available in 10 to 40 positions in straight or right-angle pin arrangements. 20-position, right-angle board-mount connector, $1.67 (1000).

Fujitsu Component of America Inc, 3330 Scott Blvd. Santa Clara, CA 95054. Phone (408) 562-1000. FAX 408-727-0355. **Circle No. 440**

LED Assembly

Mountable on pc boards, the 6310D series of right-angle LED assemblies are available with red, green, or yellow and incorporate a press-in fit for alignment and holding during wave soldering. Their pre-cut leads don't require postsoldering trimming. The units have a molded an-

ode identification mark, standoffs that permit flux washing, and a life expectancy of 50,000 hours. Their high-brightness rectangular LEDs draw 20 mA from a 2V dc supply. The units have black nylon bodies, 0.100 lead spacing, and a height of 0.215-in. $0.40 (OEM qty).
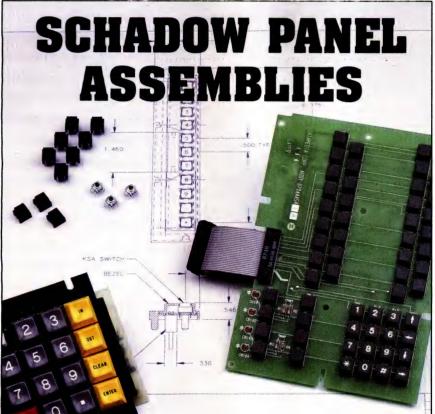
Industrial Devices Inc, 260 Railroad Ave, Hackensack, NJ 07601. Phone (201) 489-8989. FAX 201-489-6911. **Circle No. 441**

Zero-Insertion-Force PGA Sockets

Series 650 pin-grid-array (PGA) sockets are zero-insertion-force devices that accommodate arrays ranging from 10×10 to 21×21 pins. The sockets feature normally closed, dual-beam, beryllium-copper contacts. The contacts are plated with 30 μin. of select gold over 50 μin. of nickel. Designed for compatibility with fully automatic loading/unloading operations, the sockets feature a chamfered lead-in area, which eases lead insertion.

The socket insulators are made with a thermoplastic material that carries a UL 94V-0 rating. Operating range extends to 150°C. $16.99 (1000) for a 10×10 socket.

Wells Electronics Inc, 1701 S Main St, South Bend, IN 46613. Phone (219) 287-5941.

Circle No. 442

Secondar Interface Protectors

The SIP-15M/F(LAN) and SIP-09M/F(LAN) secondary interface protectors enhance the integrity of data transmissions and provide added protection for vulnerable equipment on long cable runs. The -15M/F(LAN) is fully compatible

with Ethernet standards; the -09M/F(LAN) accommodates any 9-pin RS-422 or RS-232C interface. Both models are bidirectional and feature a clamping response time of 5 nsec for each protected pin. The -15M/F(LAN) unit protects a total of eight wires—six signal and two power. The -09M/F(LAN) device protects all nine wires, clamping at either 7 or 27V, depending on the application. Each device provides grounding through its respective connector shell. $50 each.

The Cylix Corp, 2637 Townsgate Rd, Suite 200, Westlake Village, CA 91361. Phone (805) 379-3155. FAX 805-378-4551. **Circle No. 443**
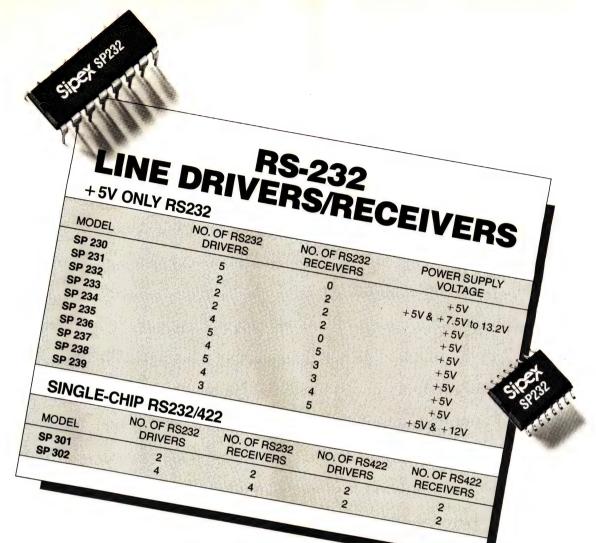
Interface Switch

In minicomputer applications, Model 8863-D 3-way transfer switch allows the computer to select among three printers. In multiple μC installations, you can use the device to switch a single printer to support three μCs equipped with a parallel interface. Because all conductors at the 36-pin connector are

Hardware

switched, the 8863-D will accommodate any parallel-interfaced printers. You can easily make all interface connections through the four 36-pin connectors (labeled A, B, C, and Common) on the switch's rear panel. The front-panel selector switch routes the data from the Common connector to the appropriate device connector. $220.

Electro Standards Laboratory Inc, Box 9144, Providence, RI 02940. Phone (401) 943-1164.
Circle No. 444

Experimenter Kits For F-O Communications Links

These kits are designed to provide hands-on experience and the latest theory on fiber-optic communications links. Topics covered include light pipes; multitone modulation of digital transmission; AM fiber-optic receivers; fiber-optic light-open-cable, single, or bidirectional communications; and digital data links. The kits include all necessary hardware such as emitters, detectors, and electronics; and simplex and duplex cables and connectors. All kits contain easy-to-follow instructions and illustrated manuals. $19.95 to $54.95.

Sintec Co, Box 410, Frenchtown, NJ 08825. Phone (201) 996-4093.
Circle No. 445

AUDIO DACs

push CD players to higher performance

Dave Pryce, *Associate Editor*

The evolution of audio DACs from 14-bit to 16-, 18-, and even 20-bit resolution is pushing the dynamic range and performance levels of compact-disk (CD) players ever higher. Taking the opposite tack is a 1-bit converter that achieves similar performance levels and threatens to upset conventional approaches to audio DAC design.

Audio DACs play an important role in determining the overall sound quality of CD players and the performance of professional recording equipment, so it's important for you to know the optimum device for your particular application. When CD players first appeared in 1982, the standard audio DAC used in the conversion process was a 14-bit device. Although its dynamic range of 84 dB exceeded that of most other components in the audio system, the 14-bit DAC quickly gave way to a 16-bit device—today's standard. The recent trend toward 18-bit and even 20-bit DACs heralds the promise of professional-level performance in consumer-level CD players. Also, a recent bit-stream technique developed by Philips promises 16-bit performance from a device that is essentially a 1-bit converter.

Before delving into the circuitry of audio DACs, it's helpful to briefly review the significance of certain DAC data-sheet specifications. Of primary importance is the DAC's bit resolution, which determines its maximum dynamic range. Theoretically, the dynamic range (in decibels) is $dB = 20 \log(2^n)$, where n is the number of bits of resolution. An easier-to-use relationship, derived from the above formula, is $dB = 6.0206n$. When rounded off, the dynamic range of a DAC is simply 6n. Obviously, a 14-bit DAC, which has a dynamic range of 84 dB, can't handle as wide a range of signal levels as can a 16-bit DAC, which has a dynamic range of 96 dB. By the same token, 18- and 20-bit DACs with dynamic ranges of 108 dB and 120 dB, respectively, offer—at least potentially—even better performance.

Perhaps the second-most important specification of an audio DAC is total harmonic distortion (THD), a characteristic that often includes noise (THD + N). THD is an indirect measure of the magnitude and distribution of a DAC's linearity errors and quantization error. THD specifications for audio DACs are extremely good; at high output levels, THD of 0.01% or less is common. At very low levels, however, THD can rise to 5% or more due to nonlinearities in the DAC's zero-crossing point.

THD is often expressed in decibels below a reference output level rather than in a percentage. For example, THD of −40 dB below an output of 0 dB is equivalent to 1%, and −80 dB is equivalent to 0.01%. To give a complete picture of the DAC's performance over a wide range of signal levels, THD usually is specified at output levels of 0, −20, and −60 dB.

Curiously, manufacturers of CD players and audio DACs specify

Audio DACs are essential to the processing of digital signals from CDs and digital audio tape. These 16- and 18-bit parts from Analog Devices are typical of the available monolithic types.
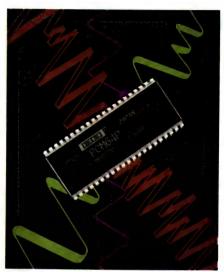
THD only at a single frequency of about 1000 Hz, a specification that doesn't tell the complete story of a CD player's typical 10-Hz to 20-kHz response. Moreover, these same manufacturers don't specify intermodulation distortion at all. Because of its peculiar nature, intermodulation distortion is very objectionable to the human ear (see **box**, "A brief analysis of distortion"). Nevertheless, the single THD+N specification is important because it has a direct bearing on the DAC's ability to handle both large and small signals, which ultimately determines its *actual* dynamic range.

Settling time is also important, because it determines the DAC's sampling rate. The standard sampling frequency for the CD format is 44.1 kHz, or 22.7 μsec. To properly reproduce the encoded digital information from a CD, the DAC's settling time should be less than this value. Many CD players employ 2×, 4×, and even 8× oversampling. To handle 8× oversampling (352.8 kHz), a DAC must settle to within 0.01% of its full-scale range in about one-half of the equatable 2.8-μsec time period.

Other traditional specifications for DACs, such as gain error and offset error, aren't as significant for audio DACs. Gain error appears as a small change in the sound volume, which is under the control of the listener. Offset error, a dc parameter, can be removed by capacitive coupling.

16-bits is standard

Although the trend is toward higher-resolution DACs capable of 18- and 20-bit performance, the majority of today's CD players use 16-bit devices. Instrumental in establishing this performance standard was the 16-bit PCM56P from Burr-

This 18-bit audio DAC from Burr-Brown features THD+N of better than −96 dB and a settling time of 200 nsec.

Brown, a company that currently supplies approximately 40% of all audio DACs used in CD players.

The PCM56P (**Fig 1**) is typical of the 16-bit DACs that have been used for several years in CD players. The device contains a serial-to-parallel shift register, input latches, an enable (pulse) generator, a clock driver, a 16-bit DAC, an output amplifier, and a voltage reference. The on-chip voltage reference enhances system performance by tracking the DAC's temperature changes. The enable generator provides the narrow pulses needed to operate the cross-coupled latches. The PCM56P arranges the bit currents so that the three MSBs use binary-weighted current sources. The next nine bits use equal current sources that are binary-weighted through an R/2R ladder network, and the LSBs use emitter division of a single current source. The output op amp, which has an open-loop gain of 90 dB, provides a 3V audio output for the CD player.

The PCM56P's performance is representative of most of the sec-

ond-generation audio DACs used in CD players. THD is −82 dB relative to an output of 0 dB, and −28 dB relative to −60-dB output. Unlike most audio DAC specifications, these THD figures don't include noise. Although these distortion levels are quite low, they're high enough to restrict the dynamic range of this 16-bit DAC to a value that's between 8 and 14 dB less than its 96-dB theoretical capability.

As with all audio DACs of this type, the PCM56P requires a low-pass filter to remove unwanted frequency components caused by the sampling process, as well as those resulting from the discrete nature of the D/A output. Such a filter must have a flat frequency response over the 20-Hz to 20-kHz audio band. At the normal sampling frequency of 44.1 kHz, a 9- to 13-pole analog filter is usually required. To avoid the nonlinear phase response of these high-order filters, systems designers often use oversampling. Oversampling by 2× would move the sampling frequency to 88.2 kHz, allowing you to use a simpler low-order filter. One PCM56P can provide 2-channel oversampling at rates of 2× and 4× and still stay within the settling-time requirements for maintaining satisfactory THD performance. The PCM56P costs $9 (1000).

A number of manufacturers offer 16-bit DACs that are similar in performance to Burr-Brown's PCM56P. Analog Devices, a company better known for its high-performance ADCs and DACs for the industrial and military markets, jumped with both feet into the highly competitive, low-cost audio DAC market about a year ago. Its AD1856N ($10.70 (1000)) offers identical specifications to Burr-Brown's PCM56P and comes in a

The dynamic range of an audio DAC is determined by its bit resolution and the magnitude of the distortion products.

pin-compatible, 16-pin DIP as well as a 16-pin SOIC package.

Philips and Sony, partners in the original development of the CD and the CD player, also offer 16-bit DACs. Philips (along with its Signetics affiliate) has the TDA1541A, a device that comes in a 28-pin DIP and features THD + N of −90 dB at 0-dB output. For low-cost applications, Philips offers the TDA1543A. This device comes in an 8-pin SOIC package and isn't as rigorously specified as its TDA1541A sibling. The TDA1541A costs $14 (1000); the TDA1543A costs $4 (1000).

Sony offers the CX20133 and CX20152, intending the latter device for dual (multiplex) applications. These 16-bit devices are similar in performance but come in different packages. The CX20133 comes in a 28-pin SOIC package, and the CX20152 comes in a 28-pin DIP. Both devices have THD + N of −86 dB at 0-dB output and a settling time of 1 μsec. Neither the Philips DACs nor the Sony devices specify THD + N at a low output level of −60 dB, which leaves the designer wondering about the small-signal performance. The CX20133 costs $10.80 (100), and the CX20152 costs $9.90 (100).

Although these and other 16-bit devices continue to serve well in CD-player applications, a definite trend is growing toward the use of 18-bit and even 20-bit devices, which offer the potential of greater dynamic range and better THD + N. Yamaha Corporation, for example, offers its YM4113B3, an 18-bit device in a 16-pin DIP. Its performance is more typical of 16-bit DACs (maximum THD is −82 dB at 0-dB output and −28 dB at −60-dB output), but the YM4113B3 does offer external adjustment of MSB errors, which permits the highest possible degree of accuracy. Moreover, the Yamaha
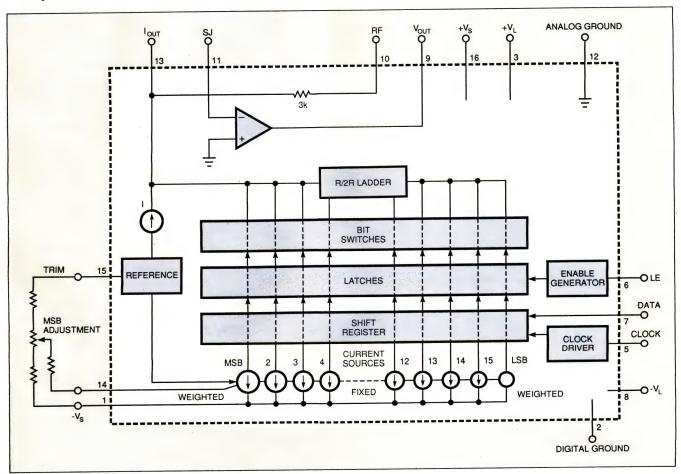
Fig 1—The architecture of this 16-bit DAC, the PCM56P from Burr-Brown, is typical of the architectures of many CD players. The device features an on-chip reference, a serial-to-parallel shift register, input latches, a pulse generator, and an output amplifier.

A brief analysis of distortion

All active—and many passive—devices exhibit varying degrees of nonlinearity, which gives rise to undesirable distortion products. In audio applications, the distortion products of primary interest are total harmonic distortion (THD) and intermodulation distortion. Manufacturers of CD players and suppliers of audio DACs specify only THD, completely ignoring the more important intermodulation-distortion specification. Moreover, manufacturers of CD players and audio DACs usually specify THD at a single frequency of about 1000 Hz, a restriction that leaves the user in the dark about most of the 10-Hz to 20-kHz response of the typical CD player.

In contrast, receivers and audio amplifiers are routinely specified for THD and intermodulation distortion over the entire 20-Hz to 20-kHz frequency range. To better understand the significance of the missing specifications, it's worth analyzing the basic characteristics of THD and intermodulation distortion, as well as their relative importance in audio systems.

Although there are limits to the amount it can tolerate, the human ear is remarkably insensitive to moderate levels of harmonic distortion. Harmonic frequencies are present in speech and in music, and people accept these harmonics as a natural occurrence. The reason for this acceptance is that harmonics are integral multiples of the fundamental frequencies that create them. For example, feeding a pure sine wave of 400 Hz into a nonlinear system creates harmonics of 800 and 1200 Hz, among others. These harmonically related frequencies sound natural to the human ear. Indeed, carefully controlled tests have shown that even the most sensitive ears can't detect THD products of less than about 1%, and many people easily tolerate levels as high as 10%.

Fig Aa shows the waveforms for a pure sine-wave fundamental frequency and its second harmonic. Although the amplitude of the resultant waveform's positive and negative alternations is changed from the original, its overall shape isn't markedly affected—a key reason why moderate levels of THD aren't objectional.

Mathematically, the THD in a nonlinear system is normally expressed as

$$THD = \frac{\sqrt{E_2{}^2 + E_3{}^2 + E_4{}^2}}{E_1}$$

where E_1 is the voltage level of the fundamental frequency, and E_2, E_3, and E_4 are the voltage levels of the second, third, and fourth harmonics. To obtain the percentage of THD, multiply the result by 100.

Normally, only the second and third harmonics are significant. For example, if the second, third, and fourth harmonics were lower than the fundamental by -40 dB, -60 dB, and -80 dB, respectively—a typical case—the THD would be approximately 1%. Neglecting the fourth harmonic in the calculation changes the result by only 0.00005%.

The THD generated by an audio DAC is the difference between an ideal sine wave at the input of the DAC and its reconstructed version at the output. For a converter with a finite number of digital inputs (samples) and associated output voltages, THD is normally calculated using the formula:

$$THD = \frac{\sqrt{1/N \sum_{S=1}^{N} [E_L(s) + E_Q(s)]^2}}{E_{RMS}}$$

where E_{rms} is the input signal level, $E_L(s)$ is the linearity error at a specific sampling point, $E_Q(s)$ is the quantization error at that sampling point, and N is the number of samples in one cycle. Again, to obtain the percentage of THD, multiply the result by 100.

In an audio DAC using pulse code modulation, the error of a particular digital code is the summation of the particular bit errors. For this reason, THD is usually measured with digitally coded sine waves of different amplitudes, which give a clearer picture of the DAC's linearity.

In contrast with its tolerance of harmonic distortion, the human ear finds relatively low levels of intermodulation distortion very offensive. A figure of 5% THD is easily tolerated by most people (often not even noticed), but an equal level of intermodulation distortion will most likely drive the same people up the wall. Intermodulation distortion has an unnatural, harsh characteristic as a result of its nonharmonically related nature.

When two sine waves of different frequencies are applied to the input of a nonlinear device, its output not only contains the original signal frequencies, but also their sum and difference frequencies. Test methods for determining intermodulation distortion involve the simultaneous application of a high-fre-

quency signal (f_1) and a low-frequency signal (f_2) to the input of the device or circuit.

One commonly used method, established by the Society of Motion Picture and Television Engineers (SMPTE), stipulates that f_1 should be approximately equal to one-half the circuit's high-frequency limit and that f_2 should be approximatetly equal to the circuit's low-frequency limit. Also stipulated is a 4:1 amplitude ratio between f_2 and f_1; that is, the level of the low-frequency signal should be 12 dB greater than that of the high-frequency signal. The most commonly used test frequencies for audio amplifiers are 7000 Hz for f_1 and 60 Hz for f_2. **Fig Ab** shows a greatly simplified waveform of intermodulation distortion in a nonlinear circuit.

Although intermodulation distortion generates many frequencies that aren't harmonically related to either f_1 or f_2, the second-and third-order terms are most important. The second-order terms are ($f_1 + f_2$) and ($f_1 - f_2$). The third-order terms are ($2f_1 + f_2$), ($2f_1 - f_2$), ($f_1 + 2f_2$), and ($f_1 - 2f_2$). As an example of the myriad frequencies generated by just the second- and third-order intermodulation-distortion terms, consider what happens with sine-wave inputs of 5000 and 100 Hz. In addition to the original signals, the nonlinear circuit's output contains frequencies of 4800, 4900, 5100, 5200, 9900, and 10,100 Hz. Note that *none* of the spurious frequencies are harmonically related to either of the two original frequencies—a characteristic that makes intermodulation distortion so intolerable to the human ear.

The specifications—or lack thereof—for CD players and audio DACS leave some unanswered questions. Why don't manufacturers of audio DACs specify intermodulation distortion, which is typically three to four times that of THD in most audio systems? Is it because they're not asked to by CD-player manufacturers? Why do manufacturers of audio DACs and CD players specify THD only at a single frequency of 1 kHz? Is it because the THD is much worse at low frequencies and at frequencies higher than about 3 kHz? A more complete list of specifications for THD and intermodulation distortion in CD players and audio DACs would satisfy the concerns of many designers.
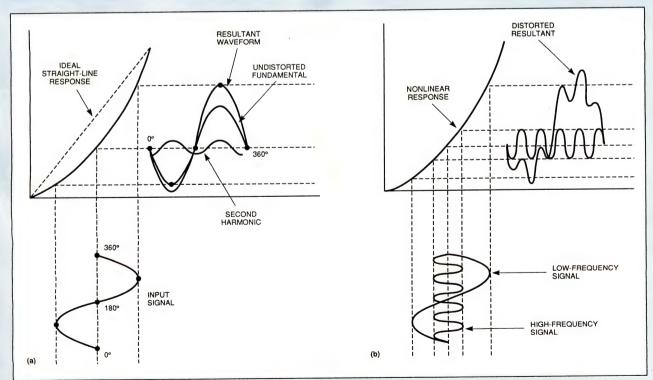
Fig A—Harmonic distortion (a) generates frequencies that are integral multiples of the fundamental frequency; intermodulation distortion (b) generates frequencies that aren't harmonically related to either of the two fundamental frequencies.

device is capable of 8× oversampling. The YM4113B3 costs $8 (1000).

Although significantly more expensive than the Yamaha device at $14.05 and $35, respectively, the 18-bit PCM58P from Burr-Brown and the 20-bit AD1862N from Analog Devices are much better examples of the enhanced performance obtainable from high-resolution DACs.

The PCM58P current-output DAC features maximum THD + N of −92 dB at 0-dB output and −34 dB at −60-dB output, a significant improvement over the 16-bit PCM56P. Moreover, the PCM58P achieves this performance without the need for any MSB adjustment. You can improve this performance by adding external bit-adjustment circuitry. The DAC also offers a fast, glitch-free settling time of 200 nsec.

Available in a 28-pin DIP, the PCM58P is designed for high-end, consumer and professional digital audio applications. Burr-Brown also offers the lower-performance 18-bit PCM61P, which comes in a 16-pin DIP and costs $9.55 (1000). Analog Devices features a similar 18-bit device—the AD1860N—for $13.95

(1000). In fact, Analog Devices was the first company on the market with an 18-bit audio DAC in a 16-pin DIP. The AD1860N is also available in a 16-pin SOIC package.

Analog Devices seems to have a penchant for stuffing as many bits as possible into a space-saving 16-pin package. Like its 16- and 18-bit devices, the company's 20-bit AD1862N also comes in a 16-pin DIP. Targeted primarily for professional audio applications such as mixing consoles and digital tape recorders, the AD1862N also brings the benefits of wide dynamic range, low distortion, and low noise to
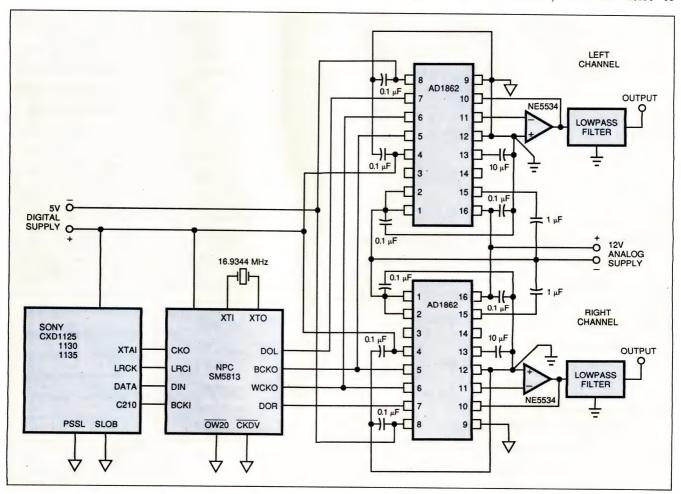
Fig 2—Featuring 8× oversampling, this circuit uses two 20-bit, AD1862 DACs from Analog Devices to achieve very low levels of harmonic distortion and a high S/N ratio.

To obtain greater dynamic range, third-generation CD players are changing from 16-bit DACs to 18- and 20-bit devices.

high-performance CD players.

The AD1862N's specifications speak for themselves: THD + N is −100 dB at 0-dB output and −40 db at −60-dB output, levels that are low enough to challenge far more expensive hybrid circuits. The DAC's S/N ratio is 120 dB, settling time is 1.0 μsec, and gain linearity is ±1 dB. Fabricated in the company's BiMOS II process, the AD1862N operates from supplies of ±5 to ±12V and ±12V.

Fig 2 illustrates a typical application for the AD1862N in a CD player using 8× oversampling. The circuit uses individual AD1862s for the left and right channels. Although this approach is more expensive than using a single DAC, it eliminates the speed constraints and other problems associated with multiplexing. The SM5813 from Nippon Precision Circuits is a digital interpolating filter that operates at 8× oversampling and sends input data to each AD1862. The Sony CXD1125 is a controller/formatter chip that supports the SM5813. The CXD1125 takes the serial data stream and converts it to data that includes handshaking; it also performs phase-locked-loop duties and includes on-chip clock circuitry. The NE5534 op amps, which feature low noise and distortion, are used as current-to-voltage converters. The output filters are 5-pole designs.

New approach to D/A conversion

The primary aim of any A/D or D/A conversion is to achieve high resolution and linearity to preserve the original analog waveform. Using conventional, multibit A/D conversion techniques (such as the successive-approximation method), the converter generates a multibit binary sample directly from a S/H analog value. Conversely, conven-

tional D/A conversion techniques (such as the binary-weighted, current-divider method) generate an analog current value directly from the multibit, binary-sample value. These techniques rely heavily on the accuracies of the analog circuit elements.

For example, a 16-bit DAC must generate a current value for the MSB that is accurate to 1/65,536 of the LSB. Some of the methods used to obtain this accuracy include laser trimming of components, segmentation of the divider networks, or simply adjusting the MSB currents by means of an external potentiometer. Theoretically, any converter having more than one bit is prone to nonlinearity due to weighting er-
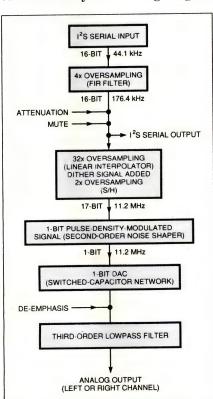
Fig 3—This flowchart depicts the operation of a unique bit-stream converter, the SAA7320, which processes 16-bit information using a 1-bit DAC. The device is available from both Philips and Signetics.

rors in the binary code. In particular, external adjustments are subject to change due to aging effects and temperature variations. To combat these problems, Philips/Signetics offers its SAA7320 bit-stream converter.

The SAA7320 is a dual-channel CMOS DAC that oversamples the 44.1-kHz sampling frequency by 256 times (see **Fig 3** for the conversion path). This high-value oversampling allows the use of band-limiting filters that are mainly digital. These filters, which are required for waveform smoothing and out-of-band noise reduction, are both costly and cumbersome when executed in analog form. In addition to the digital filters, the SAA7320 contains active components for analog postfiltering. For high-performance CD systems, an output after the 4× oversampling filter provides an interface between the decoder and an external DAC.

The major sections of the SAA7320 include a serial input, a 3-stage digital filter, a second-order noise shaper, a 1-bit DAC, and a third-order, lowpass filter. The first stage of the 3-stage digital filter provides 4× oversampling to 176.4 kHz using a 128-tap, FIR, lowpass filter. Data is stored in a cyclic RAM, the filter coefficients are stored in a ROM, and an array multiplier performs the convolutions. The second stage is a 32×-oversampling linear interpolator, and the third stage provides 2× oversampling, giving a total of 256× oversampling at a frequency of 11.2896 MHz.

The SAA7320 achieves D/A conversion using a 1-bit DAC whose second-order noise shaping is performed digitally to provide a 1-bit, pulse-density-modulated code with an S/N ratio of >90 dB. Integral

For high-performance professional applications, hybrid DACs offer the best linearity and the lowest distortion.

■

with the 1-bit DAC is a lowpass-filtering action, which reduces the total high-frequency noise power. Using switched-capacitor technology, the 1-bit DAC converts the pulse-density-modulated stream to an analog signal, which then passes through the third-order, lowpass filter to the output.

In the bit-stream D/A conversion process, the binary samples (16 bits) are converted to a high-speed (11 MHz) 1-bit data stream. Using the digital domain to transform the bit weighting in a binary sample into a 1-bit data stream eliminates MSB accuracy and the mismatching of conversion elements—the major sources of nonlinearity in multibit converters. Packaged in a 44-pin quad flatpack, the SAA7320 costs $20 (1000) and operates from one 5V supply. This unique IC features THD+N of better than −90 dB, a figure that's usually obtainable only with an 18-bit DAC. In fact, the SAA7320 may precipitate a battle with conventional 16- and 18-bit

DACs for dominance in CD-player applications.

Although the performance levels of monolithic audio DACs are pushing ever higher, they don't yet equal those of hybrid devices. Targeted for professional applications and high-end CD players, the D18400 (18-bit) and D20400 (20-bit) dual DACs from Ultra Analog are examples of hybrid devices that offer state-of-the-art performance.

Table 1—Representative audio DACs

Manufacturer	Part Number	Number of Bits	THD+N (max dB)		Settling Time (μsec)	Output		Supply Voltage (V)	Package
			$V_O=0$ dB	$V_O=-60$ dB		(V)	(mA)		
Analog Devices	AD1856N	16	−82*	−28*	1.5	±3	±1	±5 to ±12	16-pin DIP, SOIC
	AD1860N	18	−82	−28	1.5	±3	±1	±5 to ±12	16-pin DIP, SOIC
	AD1862N	20	−100	−40	1.0	—	±1	±5 to ±12, ±12	16-pin DIP
	AD1864N	18 (dual)	−82	−34	—	±3	±1	±5	24-pin DIP
Burr-Brown	PCM56P	16	−82*	−28*	1.5	±3	±1	±5 to ±12	16-pin DIP
	PCM58P	18	−92	−34	0.2	—	±1	+5, −12	28-pin DIP
	PCM61P	18	−82	−28	1.5	±3	±1	±5 to ±12	16-pin DIP
	PCM64P	18	−96	−42	0.2	—	±1	+5, −15	42-pin DIP
	PCM1700P	18 (dual)	−82	−28	—	±3	±0.67	±5	28-pin DIP
Philips (Signetics)	SAA7320	16 (1-bit DAC)	−90	—	—	1	—	±5	44-pin quad flatpack
	TDA1541A	16 (dual)	−90	—	0.5	—	4	±5, −15	28-pin DIP
Sony	CX20133	16	−86	—	1.0	—	2	±5	28-pin SOIC
	CX20152	16 (dual)	−86	—	1.0	—	2	±5	28-pin DIP
Ultra Analog	D18400	18 (dual)	−96	−46	—	±5	±1	+5, ±15	38-pin module
	D20400	20 (dual)	−100	−50	—	±5	±1	+5, ±15	38-pin module
Yamaha	YM4113B3	18	−82*	−28*	—	±3	±1	±5	16-pin DIP

*Does not include noise (N).

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MAX448	**Quad, Video Amp**	**100**	**90**	**50mA Drive**	**7.50**
MAX450	Single Video Amp	10	100	High Output Drive	2.27
MAX451	Single Video Amp	10	100	I_B = 1nA max	5.19
MAX452	Video Amp	50	150	High Output Drive	2.67
MAX453	Video Mux/Amp	50	150	2 Ch. Input MUX	3.99
MAX454	Video Mux/Amp	50	150	4 Ch. Input MUX	5.32
MAX455	Video Mux/Amp	50	150	8 Ch. Input MUX	4.86
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The D18400 and the D20400, at $120 and $200 (250) respectively, aren't inexpensive. These devices are dual DACs, however, which cut the cost per channel in half. Furthermore, you get what you pay for, and in this case, you get quite a lot.

For example, the maximum THD + N for the 18-bit D18400 is −96 dB at 0-dB output and −46 dB at −60-dB output. As you might expect, the figures for the 20-bit D20400 are even better: THD + N is −100 dB at 0-dB output and −50 dB at −60-dB output. Moreover, in contrast with lower-cost monolithic DACs, which are measured only at 1 kHz, THD + N specifications for these hybrid DACs apply over the entire 20-Hz to 20-kHz audio range. Such specifications imply a high degree of linearity—an important consideration in demanding professional and audiophile applications. In addition, both the D18400 and D20400 are capable of 8× oversampling.

To choose the best audio DAC for your application, you must take into account not only key performance specifications such as THD + N, settling time, and output capability, but also package considerations. And, of course, cost is always important. The small-quantity prices mentioned here are only representative and bear little resemblance to those of OEM quantities. **EDN**

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Dual ECL Compatible with Latch	MAX9687CPE 1.9ns/$6.33	AM6687DL 4ns/$21.00	AD9687BD 4ns/$7.06	SP9687DG 4ns/$7.04
TTL Compatible with Latch	MAX9686CPA 9ns/$3.00	AM686CN 12ns/$2.40	AD9686BQ N/A/$3.00	NONE
Dual TTL Compatible with Latch	MAX9698CPE 9ns/$4.80	NONE	NONE	NONE

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1 mV. The log amp's internal architecture minimizes thermally induced errors so that the logarithmic slope, intercept voltage, and ac response are stable over the full military temperature range.

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(-40 to +85°C) and military (-55 to +125°C) temperature ranges. Both devices are available in either 20-pin LCCs or ceramic DIPs. The industrial ceramic-DIP version costs $60 (100).

Analog Devices, Box 9106, Norwood, MA 02062. Phone (617) 329-4700. **Circle No. 677**

SIMM memory-packaging technology results in quad-density RAM modules

A new RAM-packaging technology, called Flexible Leaded Component (FLC), has resulted in a family of SIMMs (single in-line memory modules) that store four times as much data as industry-standard SIMMs. For example, a SIMM based on FLC and a 1M-bit dynamic-RAM die stores 4M bytes in the industry standard 30-pin, 1M-byte package.

The FLC makes use of a raw die and is a fully additive semiconductor package. A passivation layer of silicon nitride seals the IC; a proprietary organic dielectric encapsulates it. Conductive interconnec-

tions can be implemented with sputtering or with electroplated metal. A memory module consists of multiple FLC packages.

Initially, the technology will be used to produce dynamic-RAM SIMMs. You can now choose from 2M- and 4M-byte offerings that are compatible with the industry-standard 30-pin SIMM. The 4M-byte DSIMM408-10 and DSIMM409-10 cost $887 and $992 (100), respectively. Both models employ 100-nsec, 1M-byte dynamic-RAM ICs, and the DSIMM409-10 includes a parity bit.

The company also currently offers a 100-nsec, 256k × 16-bit static-RAM module, the SSIMM25616-100, which costs $633 (100) and is byte addressable. No industry standards exist, however, for static-RAM SIMMs.

Samples of the dynamic-RAM modules are available now, and once the products reach production stage, the lead time for custom products will only be six weeks.

Unistructure Inc, 3 Whatney Pl, Irvine, CA 92718. Phone (714) 581-0810. **Circle No. 678**
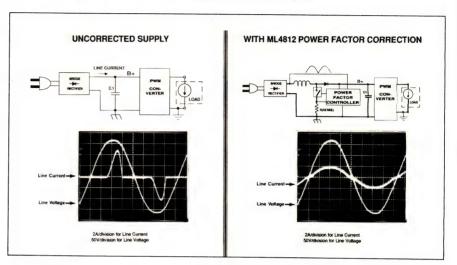
Integrated Circuits

Power-factor controller boosts power utilization and reduces line noise

To obtain the maximum amount of usable power from ac lines, your current demand should be sinusoidal and in phase with the line voltage. Power supplies without power-factor correction, however, draw current from the ac lines in pulses, using only about 70% of the power available. The ML4812 power-factor controller allows 99% utilization of available power.

The device switches input current not required by the load into an external inductor, where the unused power is stored in a magnetic field. The device can tap this field energy to fill in when the input current is insufficient. Switching between energy sources allows the power-factor controller to maintain a steady 1A output at 380V dc.

The controller also provides overvoltage protection to prevent output runaway when the load is removed. To simplify the start-up,

UNCORRECTED SUPPLY

2A/division for Line Current
50V/division for Line Voltage

WITH ML4812 POWER FACTOR CORRECTION

2A/division for Line Current
50V/division for Line Voltage

the controller has an undervoltage lockout with 7V hysteresis. Furthermore, the ML4812 provides a 5V dc reference signal accurate to ±0.5% and offers programmable ramp compensation that provides stability when the device's switching circuits exceed 50% duty cycle.

The ML4812 operates over an in-put-voltage range of 90 to 265V ac. The device comes in either a 16-pin DIP or a 20-pin plastic chip carrier. The price is $5.95 (100).

Micro Linear Corp, 2092 Concourse Dr, San Jose, CA 95131. Phone (408) 433-5200.

Circle No. 679

80386 cache controller supports as much as 256k bytes of cache memory

The MDS-C395e cache controller supports 32k-, 64k-, 128k-, and 256k-byte cache memories. The cache controller also gives you the flexibility to select one of the following mapping options: direct, 2-way set associative, or 4-way set associative.

The 2- and 4-way set-associative organizations reduce thrashing when programs jump between multiple main-memory addresses at the same page offset.

The cache controller also offers copyback in addition to write through and posted writes for maintaining main-memory coherency with the cache. Although the write-

through approach found on other cache controllers guarantees real-time coherency, it reduces system speed because writes to the cache are simultaneously written to main memory, tying up the main memory when other bus masters could be using it.

Using the copyback mode, which doesn't tie up the bus and memory, the C395e provides correct data on those occasions when a remote master attempts to read inconsistent data. The C395e does this by "snooping" for reads by any remote master of a main-memory address that is both present in the cache and that has data inconsistent with

the cache. If the controller finds such a case, it disables the main memory and provides the data out of the cache.

The C395e requires only the addition of four 8-bit transceivers and a RAM for use with an 80386. The part is available in 20- and 25-MHz versions. In early 1990, 33-MHz versions will be available. The 25-MHz 164-lead JEDEC quad flatpack costs $174 (100).

Matra Design Semiconductor, 2895 Northwestern Pkwy, Santa Clara, CA 95051. Phone (408) 986-9000. FAX 408-748-1038.

Circle No. 680

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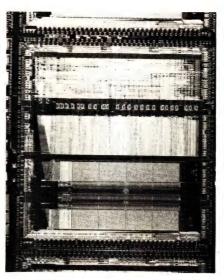
Where quality starts with fundamentals.

[1] SPICE developed by University of California

Integrated Circuits

ECL SPARC chip set operates at 80 MHz

The B5000 SPARC is a 32-bit μP that operates with clock speeds to 80 MHz and boasts a performance rating as high as 65 MIPS. Together with the B5100 floating-point controller, two B5210 register files, and the B5110/5120 floating-point chip set, the B5000 chip set uses the standard SPARC binary interface and also offers several enhancements. These enhancements include a 5-stage pipeline, cache sizes to 512k bytes, instruction prefetch with a 4-word queue, and a double-word-wide interface between the processor and cache memory.

The extra-wide interface path allows the processor to fetch one of the following combinations: instruc-

tions and data together, two instructions, or two data words. The flexible cache interface allows the

B5000 to achieve 1.2 cycles per instruction.

The chip set also offers enhanced system integrity when used in a multitasking application. If a parity error is detected during operation, the system enters a synchronous trap, which allows the operating system to determine which process has suffered the error and to abort only that process. The system will continue to operate for the other processes. The 6-chip set costs $3300/set (100).

Bipolar Integrated Technology Inc, 1050 NW Compton Dr, Beaverton, OR 97006. Phone (503) 629-5490. FAX 503-690-1498.

Circle No. 681

Cache controller for 80386-based systems handles cache exceptions internally

The A38202 cache controller connects directly to the 80386 local bus and handles processor clock rates of 25 or 33 MHz. The unit allows you to define a direct-mapped or 2-way set-associative cache using 32k, 64k, or 128k bytes of static RAM (SRAM). Because the A38202 supports the 80386's pipe-lined mode, it allows you to use slower SRAM and still achieve zero-wait-state cache hits.

The controller allows you to program as many as three regions of memory that are noncacheable for memory-mapped I/O devices and peripherals, where the processor needs access to the actual memory location instead of a copy of its contents. You can further define the internal regions to be noncacheable only on a read or write operation.

If you need more than three noncacheable regions, the controller accepts signals from external address decoding. You can also disable the cache with a single software com-

mand. If your system uses a coprocessor, you don't need any extra logic to prevent the cache from reacting to coprocessor calls. The A38202 recognizes attempts to access the coprocessor and disables the cache during these operations.

The A38202's diagnostic mode causes the device to treat the cache RAM as local memory and allows you to test the cache with the same diagnostic routines you use for main memory.

The controller comes in a 160-lead quad flatpack. The 33-MHz version costs $98; the 25-MHz version sells for $84 (10,000).

Austek Microsystems, 2903 Bunker Hill Lane, Suite 201, Santa Clara, CA 95054. Phone (408) 988-8556. FAX 408-988-0818.

Circle No. 682

Integrated Circuits

256k-bit static RAM has 35-nsec access time

Organized in a 32k × 8-bit configuration, the 256k-bit MCM6206 static RAM has a maximum access time of 35 nsec. The MCM6206 is particularly suited for use with 32-bit μPs that require larger and faster memories than their predecessors. In most cases, the MCM6206 allows the μP to operate with no wait states. PCs can also take advantage of the MCM6206's configuration for their byte-wide organization.

The MCM6206, which operates from a 5V supply, is fully static—no clock or timing strobes are necessary. Other features include an automatic power-down function that reduces power requirements, an output-enable function that allows 15-nsec access to the memory contents, and 3-state outputs.

Fabricated in the company's 1.2-μm silicon-gate CMOS technology, the MCM6206 is available in either a 28-pin plastic DIP or a 28-lead space-saving small-outline, J-leaded surface-mount package for $60

(1000).

According to the company, future members of the 256k-bit family will attain even faster performance with 1-μm processing. For example, the 64k × 4-bit MCM6208 and MCM-6209, as well as a sister device, the 256k × 1-bit MCM6207, will operate at 20 nsec. The company expects to have these products available for sampling in the fourth quarter of 1989.

Motorola Inc, MOS Memory Products Div, Box 6000, Austin, TX 78762. Phone (512) 928-6700.

Circle No. 683

EEPROM-based programmable filter handles eighth order and can be cascaded

The SC22324 CMOS programmable switched-capacitor filter allows you to implement an eighth-order filter function with a single component. The device stores the programming information in EEPROM, giving you the flexibility of a dynamically programmed device without having to reconfigure the part at power-up. For production quantities, you can replace the SC22324 with the SC11324 custom mask version.

The device is organized as four cascaded biquad filters, any of which can be selected as the output stage. Such organization allows you to use the device as a second-, fourth-, sixth-, or eighth-order filter without rewiring. You can also cascade devices to create higher-order functions. Each of the biquad sections can be a lowpass, highpass, notch, or allpass filter type with bandwidths as high as 100 kHz.

You program the filter through a 4-pin serial interface, providing 59 bits for each biquad section—4 bits for filter type and 55 bits for coefficients. A trilevel Sel pin controls whether the filter uses either this serial data or the on-chip EEPROM; it also controls the

transfer of the serial data to EEPROM.

A designer's kit comprises a programming station that connects to an IBM PC or compatible, two SC22324 devices, filter design software, and a textbook on switched-capacitor filter design.

The SC22324 costs $49 (100); the kit costs $1875. The SC11324 custom mask version will cost about $6 in production quantities.

Sierra Semiconductor, 2075 N Capitol Ave, San Jose, CA 95132. Phone (408) 263-9300. TLX 384467. FAX 408-263-3337.   Circle No. 684

Integrated Circuits

Driver IC lets logic signals control 400V circuits

The PWR-DRV1 IC has a zener diode to create its own 5V power from either dc or rectified ac voltages as high as 120V. The 5V created by the IC is available at one of the output pins, so you can supply power to additional logic.

The device has a 400V n-channel MOS power transistor that can handle as much as 275 mA of continuous current. It can also handle as much as 2A in 300-μsec pulses with a 2% duty cycle. A set-reset latch allows you to use either continuous or pulsed logic signals to turn the driver on and off. The latch responds to signals as short as 100 nsec.

Two additional features of the power driver are a current mirror to sense the load current and a comparator. The current mirror creates

an output current proportional to the load current in a 1:50 ratio. You can connect a resistor between the

mirror output and the device common to create a load-sense voltage as high as 200 mV.

The comparator has a 150-mV threshold with ±50 mV of hysteresis to prevent oscillation. Its output signal can drive as much as 5 mA, making the comparator suitable for driving an LED as an indicator. It can also be used to drive the latch-input lines, allowing you to activate the power driver with an analog signal instead of a logic signal.
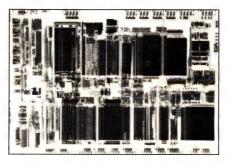
The PWR-DRV1 comes in an 8-pin plastic DIP capable of handling 750-mW power dissipation or in a 16-pin version that handles 1W. The device costs $3 (100).

Power Integrations Inc, 411 Clyde Ave, Mountain View, CA 94043. Phone (415) 960-3572. FAX 415-940-1226. **Circle No. 685**

RISC μP features 66-MIPS performance and has interrupt and DMA controllers

The i960CA RISC (reduced instruction set computer) μP regularly executes two instructions per clock cycle. The μP, offered at speeds as fast as 33 MHz, achieves a native-instruction peak-performance level of 66 MIPS. It offers code compatibility with the 80960KA μP, however, the i960CA μP includes DMA, bus, and interrupt controllers that allow you to use the processor in embedded designs with a minimum of support chips.

Key architectural features of the i960CA include parallel instruction decoding; a 1k-byte, 2-way set-associative instruction cache; multiple parallel-execution units; a multiport

register file with scoreboarding; multiple internal buses; and an onchip interface to peripheral ICs via the DMA, bus, and interrupt controllers.

Development tools for use with the i960CA include the iC960 optimizing C compiler and ASM960

macroassembler, which sell for $700 and $900, respectively, for MS-DOS-based PCs. In addition, the company offers the $750 SIM960CA performance simulator for MS-DOS applications.

The i960CA μP is housed in a 168-pin ceramic pin-grid-array package in 16-, 25-, and 33-MHz versions that sell for $273, $303, and $379 (1000), respectively. Production quantities of the i960CA will be available in the fourth quarter.

Intel Corp, Literature Dept LG42, Box 58065, Santa Clara, CA 95051. Phone in US and Canada, (800) 548-4725. **Circle No. 686**

135

Integrated Circuits

Analog/digital array is rated at 350V

The ALA501 semicustom array combines high-voltage DMOS and PMOS linear devices with low-voltage CMOS logic. Using dielectric isolation in the fabrication process, the ALA501 is free from parasitic latch-up problems that sometimes plague junction-isolated technologies.

The array uses its CMOS logic and 350V-rated DMOS/PMOS devices to accept TTL or CMOS logic inputs and to interface to high-voltage loads. The ALA501 mixed-mode array can interface directly with high-voltage power supplies or with an ac power line.

The monolithic array, which consists of four identical high-voltage tiles and four logic tiles, contains a wide variety of uncommitted active and passive components. The high-voltage section contains eight large DMOS transistors, eight small DMOS transistors, eight small PMOS transistors, and eight diodes. The large DMOS transistors' typical on-resistance is 65Ω at 10 mA.

The logic section features 35 equivalent gates of 5-μm CMOS logic in a cellular arrangement. Each cell contains five PMOS and five NMOS devices, from which it is possible to construct 2.5 equivalent logic gates. Also contained on the array are 36 ESD-protected bonding pads and a thermal shutdown circuit.

Design kits include Spice models, kit parts for breadboarding, a technical design guide, and layout plots. Pricing for the ALA501 is $6 in die form and $7 in a plastic DIP (10,000).

AT&T Microelectronics, Dept 50AL330240, 555 Union Blvd, Allentown, PA 18103. Phone (800) 372-2447; in Canada, (800) 553-2448. **Circle No. 687**

Chip set provides 1000M-bps transfer with 40-bit parallel-system interface

Both the GA9011 and GA9012 are ends of a 1000M-bps serial-data link with parallel-system interface. Using an asynchronous handshaking protocol to control data transfer, the GA9011 transmitter accepts 40-bit-wide data. It encodes the data into a 50-bit serial word with FDDI-standard (Fiber Distributed Data Interface) 4B/5B encoding, then transmits the data. The GA9012 receiver accepts the serial data, recovers the clock, decodes the data, and presents your system with 40-bit parallel data and a data-valid signal. The parallel interfaces are TTL compatible, and the serial signal is positive-referenced differential ECL.

The transmitter generates its serial clock by frequency multiplying a reference clock, either from a built-in crystal oscillator or from your system. The reference clock can range from 20 to 25 MHz, and you can set the multiplication factor to be 5, 10, 20, or 40.
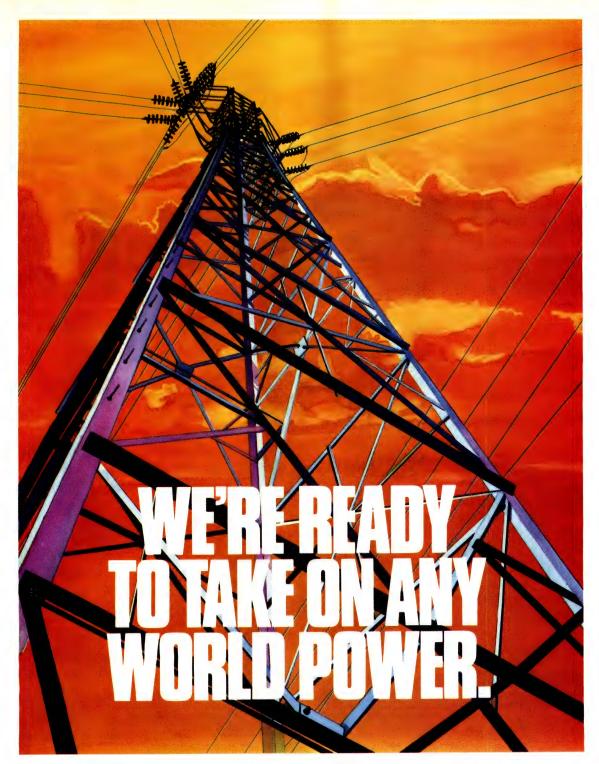
The receiver also requires a 20-to 25-MHz reference clock, but this must come from your system; the receiver has no built-in oscillator. The reference clock is the only external signal required, however. All other clock and data recovery circuits are built in and do not require external components. The receiver has limited error-detection capability and will assert an error signal if the word at its output contains an error.

The devices come in a 68-pin ceramic J-leaded chip carrier and sell for $370 (100).

Gazelle Microcircuits, 2300 Owen St, Santa Clara, CA 95054. Phone (408) 982-0900. FAX 408-982-0222. **Circle No. 688**

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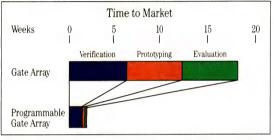
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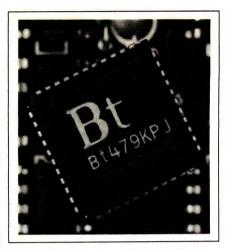
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Integrated Circuits

DAC With On-Chip RAM

The Bt479 RAMDAC overcomes the inability of today's PCs to support multiple applications and multiple windows simultaneously with unique color selections. The Bt179 enables high-end PCs to display as many as 16 windows, each capable of accessing one of four available 256×24-color palettes. The Bt479 supports as many as 1024 simultaneous colors through the $1k \times 24$-color palette RAM and triple 8-bit D/A converters. To solve the problem of overlapping windows, the Bt479 features a window-priority encoder that automatically prioritizes the windows on a pixel-by-pixel basis via stored location and priority settings. The Bt479 supports IBM VGA, enhanced VGA, and 8514A graphics standards. Bt479 35-MHz version in a 44-pin plastic leaded-chip carrier, $29 (100).

Brooktree Corp, 9950 Barnes Canyon Rd, San Diego, CA 92121. Phone (619) 452-7580. FAX 619-452-1249. TLX 383496.
Circle No. 351

Stereo 16-Bit ADC

Designed for digital-audio applications, the CS5326 high-performance, stereo 16-bit ADC uses delta-sigma conversion over a 25-kHz bandwidth. The device incorporates on-chip dual ADCs, digital antialiasing filters, digital decimation, a voltage reference, and sample-and-hold circuits. The IC has two completely independent channels and achieves a dynamic range of more than 94 dB. Harmonic distortion is <0.0015%, and the S/N ratio is more than 92 dB over a 10-Hz to 22-kHz bandwidth. The CS5326's delta-sigma design uses an oversampling ratio of $64 \times$, and the antialiasing filter exhibits <0.001-dB passband ripple and more than 86-dB stopband rejection. 28-pin plastic DIP, $48 (1000).
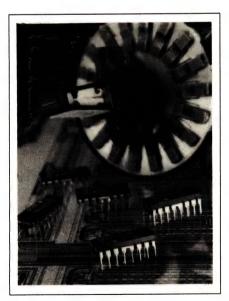
Crystal Semiconductor Corp, Box 17847, Austin, TX 78744. Phone (512) 445-7222. TWX 910-874-1352. FAX 542-445-7581.
Circle No. 352

Latched Sink Driver

The UCN5929B uses BiMOS technology to merge low-power CMOS logic with high-voltage, high-current bipolar output drivers on a single chip. The IC has three diode-clamped, open-collector npn bipolar output drivers, each capable of sinking 1.7A continuous (2A peak) and sustaining load voltages to 80V. The CMOS logic includes an externally clocked, serial-input 3-bit shift register and an externally strobed data latch for each driver. This combination supports both serial and parallel data output and allows operation with most μP- and LSI-based systems. This flexible interface allows cascaded operation when driving 9-, 18-, and 24-wire print heads as well as 66- and 132-wire line printers at rates to 2.6 MHz. On-chip protection includes high-current clamp diodes for each output driver and internal shutdown circuitry. 16-pin DIP with a copper lead frame, $2.21 (1000). Delivery, 12 to 14 weeks ARO.
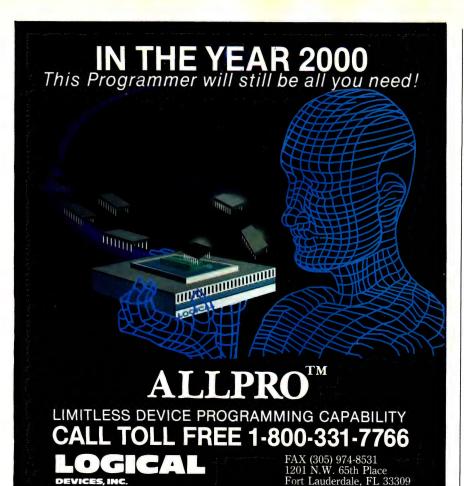
Sprague Semiconductor Group, Box 15036, Worcester, MA 01615. Phone (508) 853-5000. FAX 508-853-5049.
Circle No. 353
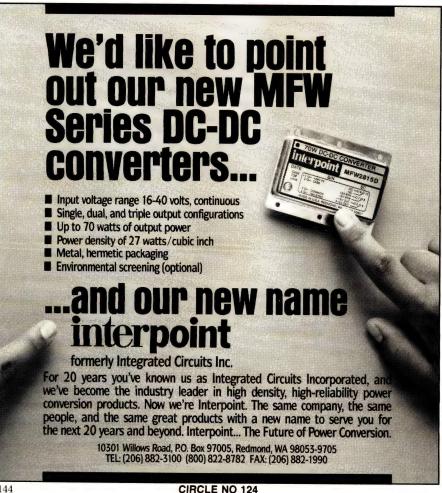
Shared-Memory Subsystem

The IDT7MB6036 is a $128k \times 16$-bit shared-memory subsystem that features a proprietary arbitration chip to prevent system deadlocks from simultaneous dual-port access. The arbitration chip selects one port and ensures indefinite exclusive access, while the busy output flag gives a busy signal to the other port. The two ports have separate address, data, and control lines to permit independent access to any location in the shared memory array.

A master/slave control lets you combine one memory in master mode with another in slave mode for wider word widths. The device has separate write controls for lower and upper bytes, so you can write to either port in 8-bit bytes. Because the subsystem allows two processors to communicate with it asynchronously, the IDT7MB6036 is ideal for multiprocessing designs. Available in a 100-pin quad in-line package on an FR-4 substrate, the

ICs

120-nsec version is $200 (1000). Faster versions, to 50 nsec, are also available. Delivery, four to six weeks ARO.

Integrated Device Technology Inc, 3236 Scott Blvd, Santa Clara, CA 95052. Phone (408) 492-8566. FAX 408-492-8674. Circle No. 354

3-Pin Memory

The DS2222 EconoRAM static RAM (SRAM) has 256 bits and comes in a 3-pin TO-92 package. Two of the SRAM's pins are for power and ground; the third multiplexes control signals, address, and data into the serial SRAM via an internal time-measurement system that compares pulse lengths to encode binary data.

The first 32 bits of the DS2222 are directly laser writable. Thus, in order to serialize or identify the devices, you can brand them with fixed data. The DS2222 uses 8-bit serial command words to instruct the memory. When set to a one, the first bit indicates a command word is being written. The next two bits address one of as many as four DS2222s on a data line. Finally, the last five bits determine whether a read or write operation is to follow; a zero in any or all of the five bits indicates a read. The SRAM consumes 50 nA in standby mode and 48 nC/memory access. $0.25 (100,000).

Dallas Semiconductor, 4350 Beltwood Pkwy, Dallas, TX 75244. Phone (214) 450-0400. FAX 214-450-0470. Circle No. 355

How to get 32-bit Cache into a restricted area:

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Who Says It Can't Be Done?

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You're familiar with IDT's dual-port memories. Today IDT introduces the world's first true *four-port* memories for faster, more efficient multi-processing. Now you can do something never before possible — you can communicate between CPUs, DSPs, and controllers with *no wait states at maximum clock speeds!*

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Santa Clara, CA 95052-8015
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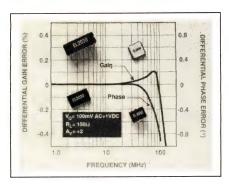
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CIRCLE NO 126

Integrated Circuits

Current-Feedback Amp

The EL2030 achieves 120 MHz of small-signal bandwidth for Av = +1 and remains as high as 95 MHz for a gain of 10. The current-feedback amplifier can achieve 30 MHz when driving a 200Ω load from −10 to +10V. Slew rate for the EL2030 is 2000V/μsec, and settling time is 40 nsec to 0.25% for a 10V step.

On ±5V supplies, the EL2030 maintains a 120-MHz bandwidth for a gain of 1 and a 90-MHz bandwidth for Av = +2. The device shows differential gain distortion of 0.01% min and differential phase of 0.01°. The amp can supply as much as 65 mA of output current. In commercial (-25 to +85°C) or military (-55 to +125°C) grades, from $4.15 (100).
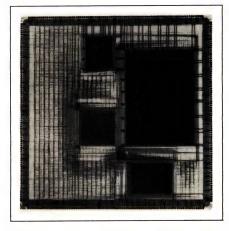
Elantec Inc, 1996 Tarob Ct, Milpitas, CA 95035. Phone (408) 945-1323. FAX 408-945-9305.
Circle No. 356

Embedded Cell Arrays

The LEA100K embedded array combines features of gate arrays and cell-based designs. Supported by the vendors' modular design environment, the LEA100K has a number of specialized circuit blocks that you can embed in your design.

Among the memory blocks are static RAMs to 144k bits, multiport RAMs with as many as five ports, contact programmable ROMs as large as 1M bits, FIFOs, LIFOs, and content-addressable memories.

Other megafunctions available include microprocessors, floating-

Wanna see them again?

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You may have *heard* of a faster SRAM. Maybe you've even seen one—some lone sample somewhere. But there are no faster, denser SRAMs in production anywhere than these new devices from National.

We've been shipping our 256Kx1 for more than 18 months. Now production quantities are also available of our new 64Kx4 and 16Kx4. And more new SRAMs are on the way.

Our family is not only growing fast, it's growing faster. The 256Kx1's already-fast access time of 15 ns has been cut to 12 ns for the 64Kx4. And to 10 ns for the 16Kx4.

THE DIFFERENCE IS BiCMOS III.

National's proprietary BiCMOS III one-micron process— which we've been running for more than two years—combines the speed of pure bipolar with the high density, low power, and manufacturability of CMOS.

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The original BiCMOS 256Kx1 at 15 ns

The new BiCMOS 64Kx4 at 12 ns

That's why Cray Research has been one of our biggest SRAM customers. BiCMOS III gives them the best ratio of speed, power and cost per bit.

And we designed reliability into the process from the beginning. In fact, one-third of the development team had reliability as their sole responsibility.

The pay-off is a life-test failure rate of less than 50 FIT with more than 400,000 device hours. And soft-error rates as low as 20 FIT at 5.2 volts VEE. So you'll have fewer system problems and less need for error detection and correction.

YOU'LL SEE THE DIFFERENCE IN SYSTEM PERFORMANCE.

Because of their stable memory cells, these new SRAMs tolerate skewed address signals without disturbed bits.

NATIONAL ECL SYSTEM SOLUTIONS

BiCMOS ECL I/O SRAMs
ASPECT™ gate arrays
ASPECT™ standard cells
FGE gate arrays
ECL PALs
F100K digital logic

The new BiCMOS 16Kx4 at 10 ns

Customers like HiLevel Technology also report low system noise and cleaner, quieter, faster signals. This high noise immunity is due to on-chip decoupling and minimal di/dt.

Unlike other SRAMs, these devices allow almost a third of the cycle time for system skews, so you can easily design them in and achieve rated speeds.

Our ECL I/O SRAMs are input/output compatible with existing 10K and 100K ECL parts. Industry-standard pin-outs enable multiple sourcing.

TAKE A LOOK AT OUR OTHER ECL PRODUCTS.

In addition to our BiCMOS SRAMs, we offer a variety of other ECL products in areas critical to high-speed applications. They're worth a second look.

But call today because our BiCMOS ECL I/O SRAMs are going fast. Call toll-free (800) 825-5805, ext. 115.

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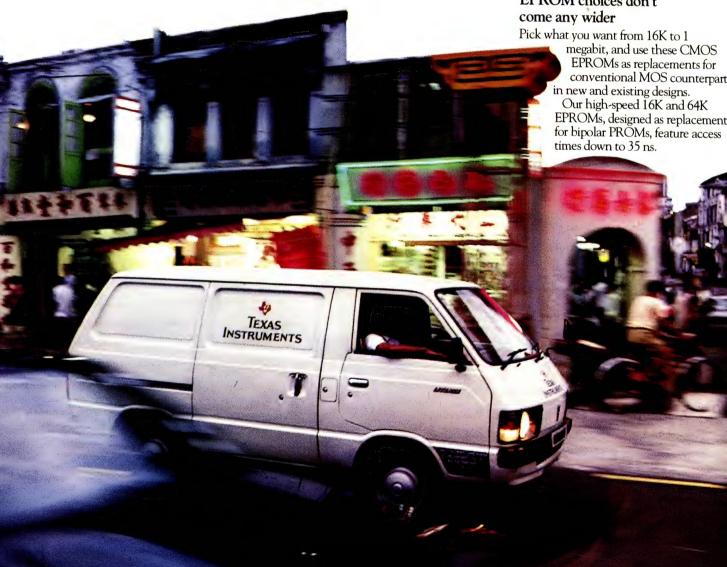
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point controllers, communications controllers, adders, multipliers, barrel shifters, ALUs, and assorted Motorola-, Intel-, and AMD-compatible peripherals. According to the vendor, you can create an optimized design of as many as 150,000 gates. Packaging options include plastic and ceramic DIPs, leadless- and leaded-chip carriers, pin-grid arrays, and quad flatpacks. Nonrecurring engineering charges, from $20,000; unit price from $2 in large quantities.

LSI Logic Corp, MS D102, 1551 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 433-8000.

Circle No. 357

Precision Absolute Value Circuit

Dual Op Amp

Featuring an input offset voltage of 30 μV max with V_{OS} drift of 0.5 μV/°C max, the RC4277 is a high-performance dual op amp that comes in an 8-lead package. The open-loop gain for the device is 2 million min into a 2-kΩ load, and input bias current is ±3.0 nA max; power consumption is 100 mW max for both channels. CMRR and PSRR of 120 dB min support the high precision of the RC4277. The op amp uses SiCr thin-film resistors and postpackaging trimming of the input offset voltage to improve device performance. The RC4277 replaces OP-200, OP-207, LT1002, OP-07, and OP77 amplifiers. Proc-

essing to MIL-STD-883 level B is available. From $2.95 (100).

Raytheon Co, Semiconductor Division, 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211. TWX 910-379-6484.

Circle No. 358

2- And 3-Chip Sets

The VL82C286 is a 2-chip set for 25-MHz and slower, 80286- and 80386SX-based systems, and the VL82C386 is a 3-chip set for 33-MHz and slower, 80386-based systems. The 2-chip C286 consists of a system controller/data buffer and an ISA (Industry Standard Architecture) bus controller. The 3-chip C386 partitions the system controller and data buffer to separate ICs. Both sets support 256k-, 1M-, and 4M-bit dynamic RAMs and contain power-down control features for low-power applications. The two sets also provide extended-memory-specification hardware support for LIM 4.0 (Lotus, Intel, Microsoft) over the entire memory map.

The C286 integrates a timer IC, a real-time clock IC, two interrupt controller ICs, and two DMA controller ICs with an extended page register IC. The set supports the Intel 287 or 387SX coprocessor. In contrast, the C386 supports either the Austek or Intel cache controllers and the Weitek or Intel numeric coprocessors. VL82C286, $160 (sample qty); $80 (May 1990, 1000). VL82C386, $185 (sample qty); $95 (March 1990, 1000).
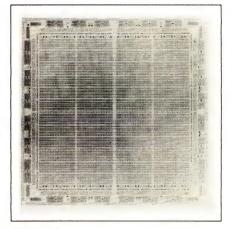
VLSI Technology Inquiries, 200 Parkside Dr, San Fernando, CA 91340. Phone (602) 752-6200.

Circle No. 359

Smart Power IC

The TLP404 intelligent power IC provides fault feedback when it detects open-load, short-to-ground, thermal-shutdown, overvoltage-shutdown, or short-to-V_{CC} conditions. In addition, protection circuitry in the four op-amp power switches limits output current to 1A. Because each op amp operates independently, a fault on one channel doesn't affect the operation of any other channel. Other features of the TLP404 include an output-voltage rating of 45V max, and protection from power-supply transients to 45V and reverse-battery conditions to 13V. The intelligent power IC is available in a 15-pin, 25W SIP and has been characterized for operation from −40 to +125°C. $4.87 (1000).

Texas Instruments Inc, Semiconductor Group, Box 809066, Dallas, TX 75380. Phone (800) 232-3200, ext 700. Circle No. 360
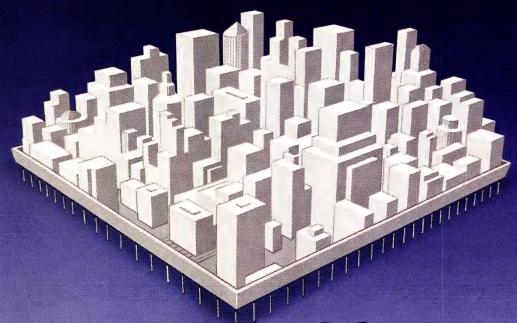
ECL Gate Array

Offering 240-psec (typ) gate delays on a 3-mm metal line while driving a 3-gate load, the E30000VH ECL gate array guarantees clock skew of <150 psec. However, the penalty for high speed is high power consumption—the array typically dissipates 15 to 30W. Its gate counts range from 29,568 to 38,948. Unlike CMOS, where four transistors typically comprise a gate, the gate

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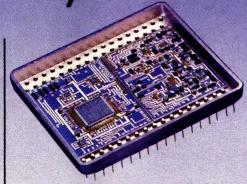
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Vitelic now offers 256K x 8 or 9-bit memory modules utilizing our high performance CMOS DRAMs. Available in fast page and static column modes, as well as standard 30 lead SIMM and SIP versions, our memory modules will have your PCs or workstations cutting powder with the most advanced equipment on the slopes.

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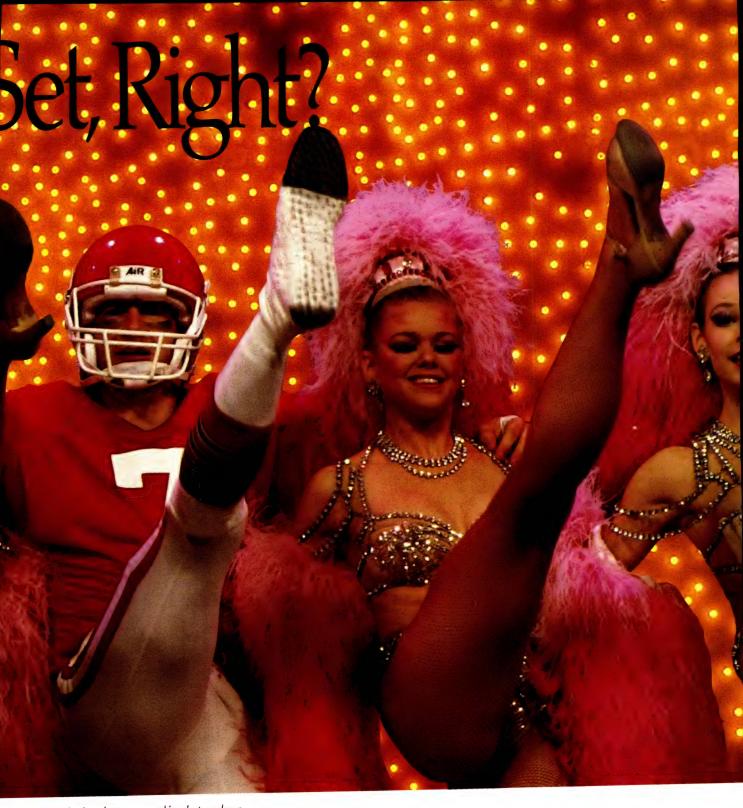
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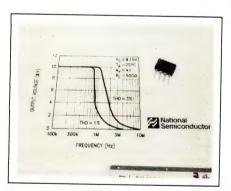
Integrated Circuits

count in ECL is dependent on how you use the transistors.

The array offers 300 I/O pins with more than 200 pins usable as outputs. Two I/O options allow you to use the array with either 10KH (−5.2V) or 100K (−4.5V) ECL logic systems. In addition, the array requires a −3.3V supply. The interconnections among the gates are via 4-level metallization; three of these levels are for signal routing.

Design input is being accepted now, and engineering samples and production quantities will be available in the first and second quarters of 1990, respectively. In a 441-pin, ceramic, surface-mount pin-grid array with 50-mil spacing, $1600 (1000). Approximate turnaround time from design approval to engineering samples is 13 weeks.

Fujitsu Microelectronics Inc, Integrated Circuits Division, 3545 N First St, San Jose, CA 95134. Phone (408) 922-9000. FAX 408-432-9044. Circle No. 361
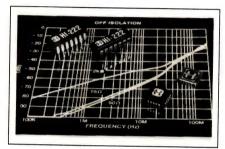
High-Speed Op Amp

Manufactured using the company's VIP (vertically integrated pnp) process, the LM6218 dual op amp achieves a 0.01% settling time of 400 nsec. This fast time allows the use of the device in data-acquisition systems that require 12-bit precision. Compared with earlier VIP products, the LM6218 offers a better open-loop gain of 500V/mV and a lower offset voltage of 3 mV. The device's slew rate is 140V/μsec, its unity-gain bandwidth is 17 MHz, and its pnp input stage has a bias

current of only 200 nA. It operates over ±5 to ±20V and has a full-power bandwidth of 700 kHz at 1% THD with a ±10V output signal. In an 8-pin DIP, $4.65 (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-2281. TLX 346353. Circle No. 362

High-Frequency Video Switch

The HI-222 high-frequency spst switch has an operating bandwidth that exceeds 200 MHz, and features a 35Ω on-impedance and switching speeds of 100 nsec. The use of dielectric isolation in the fabrication process allows complementary npn-pnp circuit design that provides broadcast-quality differential gain- and phase-error performance of 0.03% and 0.003°, respectively. The TTL-compatible device uses a T-switch design that provides −65-dB off-isolation and −80-dB crosstalk performance at 10 MHz. The HI-222 is available in three temperature ranges and in a variety of package styles, including a 14-pin plastic DIP, a 14-pin ceramic DIP, and a 20-pin PLCC. $4.67 to $21.40 (100).

Harris Semiconductor, Box 883, Melbourne, FL 32901. Phone (407) 724-3800. Circle No. 363
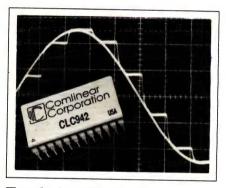
Fast 1M-Bit Dynamic RAMs

Configured as 256k-bit × 4 and 1M-bit × 1, respectively, the HM574-256JP and HM571000JP 1M-bit BiCMOS dynamic RAMs (DRAMS) offer 45-nsec access times via 16 ad-

dress pins. The pins let you load an address in a single step, rather than the 2-step operation of 8-pin address buses. The BiCMOS DRAMs each operate from a single 5V supply and draw 0.11 mA at 70 nsec. The parts come in 28-pin SOJ packages and are available in engineering samples now with full production scheduled for the first quarter of 1990. $65 (1000).

Hitachi America Ltd, Semiconductor and IC Division, Hitachi Plaza, 2000 Sierra Point Pkwy, Brisbane, CA 94005. Phone (415) 589-8300. FAX 415-583-4207. Circle No. 364

Track-And-Hold IC

With a settling time to 0.01% of 25 nsec, the CLC942 track-and-hold IC provides 12-bit performance with a sampling capability to 20M samples/sec. The CLC942's input and output buffer amplifiers combine with a low-jitter sampling bridge to provide stable operation. Other important parameters include 1.4-psec (rms) aperture jitter, second-harmonic distortion of −74 dBc at 4 MHz and −50 dBc at 20 MHz, and third-harmonic distortion of −75 dBc at 4 MHz and −64 dBc at 20 MHz. The feedthrough rejection ratio is −78 dB at 20 MHz. The CLC942 comes in a 24-pin, side-brazed ceramic package. From $139 (100).

Comlinear Corp, 4800 Wheaton Dr, Fort Collins, CO 80525. Phone (303) 226-0500. FAX 303-226-0564. TLX 450881. Circle No. 365

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An entire data channel using this 5-volt family is capable of operating on a stingy 750mW while still providing high performance. Alternate design solutions often consume as much as two to three times more power. In addition to low operating power, two independent power-down states are provided. The first is a sleep state included in each device for power savings during idle conditions. The second state, contained in the 32P548, powers down circuitry not required during servo acquisition.

The 32P548 comes in a 52-pin fine-pitch quad flat pack (body 390 x 390 mils) and the 32R1200, 32R4610 Read/Write devices are available in standard 16-pin and 20-pin SO packages.

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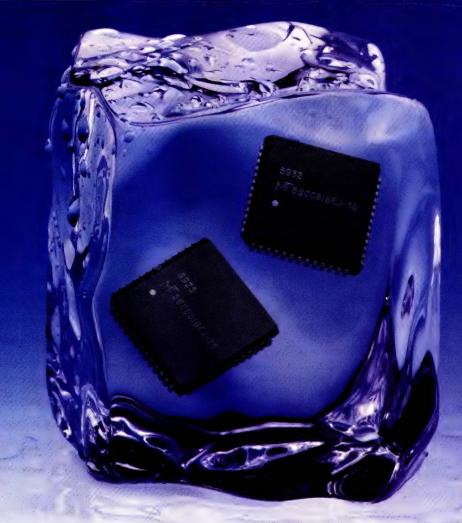
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25 MHz	35ns	13ns

*All timing rated at 100 pF loads. The MT56C0816 is available in a 52-pin plastic leaded chip carrier (PLCC).

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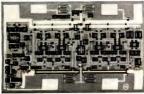
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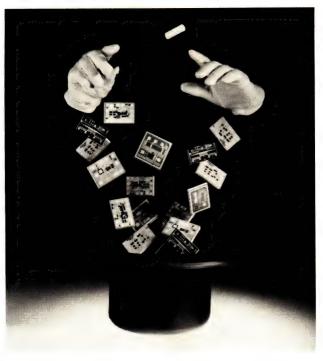
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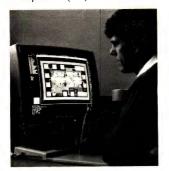
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Magic Solutions in Silicon

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Integrated Circuits

1M-Bit Video RAMs

Organized in two different configurations, these 1M-bit video RAMs are available with maximum access-time ratings of 80, 100, and 120 nsec. The M5M482128 dual-port dynamic RAM has a 128k×8-bit dynamic RAM parallel-access memory port combined with a 256×8-bit serial-access memory (SAM) port. The M5M442256 has a 256k×4-bit DRAM port combined with a 512×4-bit SAM port. The parallel port acts as a standard DRAM accessed by a μP or video controller. The bidirectional SAM port, which allows high-speed conversion of parallel data to a serial bit stream or vice versa, shifts the DRAM data out to a RAM DAC for display on a CRT. The inclusion of both ports in a single device improves performance and reduces external logic requirements. Depending on type, package options include 40-pin and 28-pin SOJ packages, and 28-pin ZIPs. 80-nsec versions, $57.50 and $62 (100).

Mitsubishi Electronics America Inc, 1050 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 730-5900. **Circle No. 366**
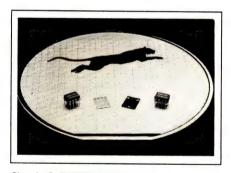
Switched Capacitor Monolithic Filters

The Max263 and Max264 are pin-programmable, switched-capacitor monolithic filters with center-frequency input ranges from 0.4 Hz to 57 kHz (Max263) and 1.0 Hz to 140 kHz (Max264). Each part has two programmable second-order filter sections, which you can use to implement lowpass, highpass, bandpass, allpass and band-reject filters. Each filter has three outputs (lowpass, bandpass, and highpass/notch) that you can use simultaneously. The center-frequency range is programmed by a 6-bit digital input. The selectivity (Q) for each section is programmed by a 7-bit digital input, which allows a range of Q from 0.5 to 64. The low noise (100 μV rms) of the devices represents less than ½ L25sb349 in a 12-bit data-acquisition system. PC-based, menu-driven software is available that reduces the design time of nth-order filters to minutes. Both of the filters are available in 24-pin DIPs, ceramic DIPs, and SOIC packages. From $6.50 (1000).

Maxim Integrated Products, 120 San Gabriel Dr, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No. 367
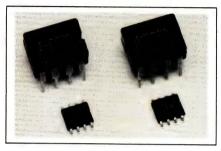
Serial EEPROMs

The CAT35C704 and CAT35C804 are password-protected serial EEPROMs that allow the user to limit access to stored data via a highly secure access-control feature. You can configure both devices as either 512×8-bit or 256×16-bit memories and guarantee 10-year min data retention and 10,000 write/erase cycles. The 35C804 differs from the 35C704 only in its onboard UART for data transfers to 9600 baud. The 35C704 uses a synchronous, high-speed communications protocol. The EEPROMs provide two operating modes: unprotected and password protected. In the protected mode, the access code can be 1 to 8 bytes long and can provide as many as 1.86×10^{19} combinations. CAT35C704, $16; CAT35C804, $18 (100).

Catalyst Semiconductor Inc, 2231 Calle De Luna, Santa Clara, CA 95054. Phone (408) 748-7700. FAX 408-980-8209. TWX 510-601-7631. **Circle No. 368**

Precision Micropower Op Amp

Optimized for operation from a single 5V supply, the LT1077 precision, micropower op amp is also fully specified for operation from a ±15V supply. Operating at a supply current of 60 μA (max), the LT1077 features an offset voltage of 40 μV (max) and an offset current of less than 0.35 pA. The op amp's 0.1- to 10-Hz peak-to-peak voltage and current noise are 0.5 μV and 2.5 pA, respectively. The gain-bandwidth product is 250 kHz. Pin compatible with other industry-standard precision op amps, the LT1077 offers 10 to 60 times lower power dissipation, according to the company. The device is available in 8-pin plastic or ceramic DIPs, 8-pin small-outline packages, and metal cans. Commercial, industrial, and military temperature ranges are available. From $1.65 (100).

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (800) 637-5545.

Circle No. 369

Ferroelectric IC

Compatible with industry-standard 74HCT logic, the K74CF372 is an 8-bit, flip-flop logic IC that saves its states in nonvolatile memory.

Now that we've been properly introduced,

Intel To Show 2-Mb, 4-Mb EPROMs

By David Roman

TOKYO — Intel Corp. chairman Gordon Moore will introduce his company's highest-density EPROMs at a press conference here tomorrow.

Intel executives are flying to Tokyo to take the wraps off two 2-megabit EPROMs and one 4-Mbit EPROM to demonstrate the company's commitment to the Japanese market.

Though Intel is the world's leading producer of EPROMs, the company owns less than 5% of Japan's EPROM market, said Tom Price, marketing manager of Intel's Programmable Memory Operation.

Intel owned 18% of the world's $1.8 billion EPROM market in 1988, according to Dataquest Inc.

The Japanese market has been quick to pick up high-density EPROMs, Price said. and Intel is hoping t some market its 128 which is

× 8 (2-Mbit) part; and a 4-Mbit EPROM organized as 256-K × 16, which will be in production in August.

Moore said these chips could reduce the number of memory chips in a system up to 75% while facilitating the design of more-compact systems.

Fujitsu Ltd., NEC Corp. and Toshiba Corp. are the only manufacturers shipping either 2- or 4-Mbit EPROMs, according to Dataquest industry analyst Mary Olsson.

Though Japanese suppliers made their public announcements of 2- and 4-Mbit EPROMs before Intel did, Price said Intel is determined to ramp very quickly to volume production.

Intel's swift ramp-up of its 2- and 4-Mbit EPROMs will bring selling prices down quickly in terms of cost per b parts will

ration costs $55 apiece; the 25 K × 8 configuration costs apiece in 10,000-piece qu ties. Faster, 150-ns vers all the new EPROMs w for about 25% more.
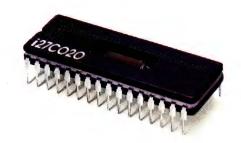
The byte-wide (256 part comes in a 32-p while the 16-bit come in 40-pin c 32-pin and 40-pin the same ones Mbit EPROM word widths future EPF density,
Intel surf M

Intel's Moore: In Japan to show off his company's densest EPROMs.

The Intel parts are all produced with the same 1-micron CHMOS process Intel uses to build 80386 microprocess pany plans to 1.2-micro productio

Intel erweitert EPROM-Spektrum nach oben

2- und 4-Mbit-EPROMs in 1,0-μm-CMOS-Technologie

002 Ein 4-Megabit-EPROM und zwei Architektur-Varianten des 2-Megabit-Typs hat Intel vorgestellt. Die neuen Speicherbauelemente werden in 1-μm-CHMOS-III-E Technologie gefertigt und haben Zugriffszeiten zwischen 150 und 200 ns. Die bereits in Mustern verfügbaren Bausteine, deren Massenproduktion im August anläuft, sind auch im PLCC-Gehäuse erhältlich.

Das EPROM 27C240 ist ein nichtflüchtiger Speicher mit einer Kapazität von 4 Mbit, organisiert zu 256K × 16 bit, und mit 150 oder 200 ns Zugriffszeit verfügbar. Es hat ein 40poliges Keramik-DIL-Gehäuse nach Jedec-Standard und ist aufwärtskompatibel zu Intels 1-Megabit-EPROM 27C210 im 40poligen DIP. Um den unterschiedlichen Systemauslegungen und Prozessorbuserfordernissen entgegenzukommen, bietet Intel auf der 2-Megabit-Ebene zwei Architekturen an. Das EPROM 27C220 ist zu 128K × 16 bit organisiert und bietet mit seinem 40poligen Keramik-DIP ebenfalls eine direkte Nachrüstmög-

lichkeit vom 1-Mbit-Typ 27C210. Diese Architektur ermöglicht den wirtschaftlichsten und kompaktesten Platinenentwurf für Systeme wie etwa Personalcomputer, die lediglich ein oder zwei EPROMs zum Speichern von Boot-Code oder BIOS-Software benötigen.

Das 2-Mbit-EPROM 27C020 organisiert zu 256K × 8 bit und untergebracht im 32poliger DIP, eignet sich optimal für leistungsstarke Mikroprozessor-Schaltungen mit zahlreichen, in Speicherbänken angeordneten EPROMs, die komplexe Programme oder grosse Datenmengen speichern. Typische

NEWS JAPAN

では インテルは に使ってもらうには がかかる。ただ、多 顧客の姿勢も変 ていただきたい さて、今回発表された EPROM だが、アクセスタイ と200n/s。 従来の27C240 は1Mビッ 210EPROM のアッ これとピン、 っている。 BIOS ソフトをストアするパ コンのようなシステムに適した メモリだ。 もう1種類の 2 M EPROM (256K×8)27C020は、高性能組 み込み制御システムなどに最適。 たとえばページプリンタのよう に、複雑なプログラムや大量の コード記憶に多数の EPROM を使用するシステムでの利用が 考えられる。いずれもサンプル 出荷は始まっているが、量産に 入るのは今年9月からだ。 インテルでは今後、メモリビ ジネスとして EPROM とフ ッシュメモリを中心にビジ を展開していくという。 まで DRAM に

take me home.

Recently, we announced our commitment to 2- and 4-Mbit EPROMs. And now, we're shipping our 2-Mbit EPROMs in volume. With our 4-Mbit EPROMs right behind them.

But, this high-speed ramp should hardly come as a surprise. After all, we invented the EPROM and have always been the volume leader.

And we've produced this latest generation with the same proven 1-micron CHMOS*IIIE process as our 1-Mbit EPROMs. So we can deliver 2-Mbit production quantities in no time at all.

As you can see from the chart, we're the EPROM source you've been looking for. Only Intel gives you the widest range of densities, from 16K to 4-Mbit. And that's just the beginning. We also let you choose byte-wide or word-wide architectures. PLCC or CERDIP packaging. And a range of speeds, from 120 ns to 200 ns.

But whichever Intel EPROM you choose, the benefits are obvious. Using one 2-Mbit instead of eight 256K EPROMs, for example, results in reduced board space, increased system reliability and

*CHMOS is a patented process of Intel Corp.

overall lower system cost.

Our 1- and 2-Mbit EPROMs are available today in whatever quantity you need. More importantly, our 1-Mbits are your most cost-effective solution now, followed by our 2-Mbits in 1990. Or you can design in our 4-Mbit EPROMs today. They'll be available in full volume and

Available in Volume	Product	Organization	Pins	Package
1-Mbit	27C010	128K × 8	32	CERDIP
	27C010	128K × 8	32	PLCC
	27C210	64K × 16	40	CERDIP
	27C210	64K × 16	44	PLCC
2-Mbit	27C020	256K × 8	32	CERDIP
	27C220	128K × 16	40	CERDIP
4-Mbit	27C240	256K × 16	40	CERAMIC

in a full range of configurations for your next generation of products.

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CIRCLE NO 135   173

The IC stores data provided to its inputs on every positive clock transition and recalls stored data to its outputs when the recall signal is given after repowering the system. The K74CF372 features data retention of more than 1 year between uses after 10^{11} data changes. It also features a 300-kHz access rate for fast parameter storage. Fabricated in low-power CMOS, the device needs <1 mA of current in the active state. 20-pin ceramic DIP, $8.50 (100).

Krysalis Corp, 1135 Kern Ave, Sunnyvale, CA 94086. Phone (408) 749-7390. FAX 408-749-7390.

Circle No. 370

Display Driver

The AMFDD frequency display driver contains two 7-segment LED drivers for use in a 2-digit, floating-point display of a personal computer's operating frequency. Designed for use in computers with multiple system-clock frequencies, the complete display unit with the autoswitching FDD chip will display a frequency range of 0.1 to 39 MHz. The display unit need only consist of two common-anode LEDs, two resistor packs, and an FDD chip. The FDD continuously samples the system clock and automatically reconfigures itself to display the correct frequency, without the need to change jumper settings in the PC. The input to the display unit consists of four lines that interface with the system clock, reference clock, and the power signals. 20-pin DIP, $4.95 (100).
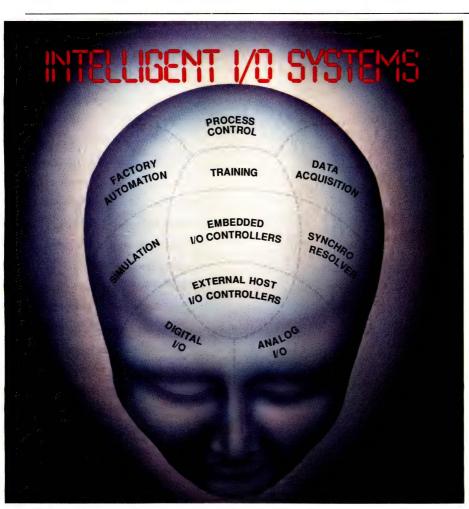
Amax Applied Technology Inc, 3001-A W Mission Rd, Alhambra, CA 91803. Phone (818) 300-8828. FAX 818-282-9992. Circle No. 371

I/O Controllers

Designed for PC I/O applications, the SAB 82C250-N and SAB 82C251-N contain both serial and parallel ports. The 82C250-N integrates two serial I/O ports with a parallel (bidirectional) printer interface. The 82C251-N contains one serial I/O port and one parallel interface. The 82C250-N is pincompatible with the industry's 16C452; the 82C251-N is pin compatible with the 16C451. The devices offer the additional capability of using the parallel port in IBM PS/2 register-compatible mode. The serial output ports are fully compatible with the SAB 16C450. In 68-pin plastic leaded-chip carriers: SAB 82C250-N, $10; SAB 82C251-N, $7 (1000).

Siemens Components Inc, Integrated Circuit Div, 2191 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 980-4526.

Circle No. 372

Thanks to Elantec, video design engineers are no longer worried about going in the red.

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HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS

FAST-CHARGE BATTERIES

team with control circuits to serve portable equipment

C hoosing a fast-charge rechargeable battery for portable equipment without considering charging methods is like solving half of an equation. Although battery chemistry and its related electrical specifications are important aspects to consider, your customer's anticipated use of your equipment—and thus the battery—is equally important.

And if you're interested in fast-charge systems, you'll have a lot to consider. Fast charging requires a fast-charge battery, a high-output power supply, a charging circuit more complex than that required for standard charging, and lots of engineering time, which collectively add up to higher system costs.

The first aspect of these costs is the battery itself. Fast-charge batteries—the adjective's somewhat loose definition includes batteries that can charge in 15 minutes to 1½ hours—have been available since the early 1970s when General Electric's battery division, now a part of Gates Energy Products, introduced its PUP-15 15-minute-charge NiCd battery. More recently, many other manufacturers including

Gates have introduced fast-charge batteries. Most of these batteries have ratings of 1- to 1½-hour charge times. Gates' Gemax; Panasonic's R-, R/P-, and S-type NiCd batteries; Sanyo's fast-charge Cadnica line; and Saft's VE series of NiCd batteries all can charge in 1 to 1½ hours. Many quick-charge batteries—those that charge in three to five hours—can also handle fast charging. Tadiran rates its line of quick-charge batteries for both 4½- and 1½-hour charges. And Eveready announced its Generator, a consumer 1-hour battery and charger system, in the beginning of 1989. Typically, you'll pay a 10 to 20% premium for fast-charge batteries. Prices range from under $1 (OEM quantities) for Gates' 650-mAhr AA battery to $11.79 (1000) for Tadiran's F-size, 6.7-Ahr battery. C- and D-size batteries cost about $4 each.

Although these are examples of NiCd batteries, fast-charge batteries are also available in other battery chemistries. Sealed lead-acid batteries rated for a 1-hour charge are available from Gates and Panasonic. Rechargeable lithium batteries can't be fast or quick charged for safety reasons. Besides, lithium batteries are most often used for backup power, so most of their applications do not call for fast-charge capability. Nickel-metal-hydride batteries are a relatively new entry into the rechargeable battery field; only one company, Ovonic Battery Co, produces them for the OEM market. Nickel-metal-hydride batteries are very similar to nickel-cadmium types, and their charge regimes are virtually identical. The C-size Ovonic cell can handle a 1-hour charge rate.

The charge, or C rate, is one way to determine whether a battery and charging system is characterized by the term fast charge. The C rate is

Fast-charge batteries can charge in 15 minutes to 1½ hours, but their use demands complex and powerful charging circuits.

Anne Watson Swager,
Associate Editor

The Generator system charges AA, C, and D batteries in 1 hour using a $-\Delta V$ charge-control circuit with a timer backup circuit. Eveready's compact charger charges as many as four AA batteries at once.

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a scaling parameter for current flow and is related to the number of amperes or milliamperes equal to the capacity rating of the cell. For instance, the 1C rate for a 1-Ahr-capacity cell is 1A. Both the charge and discharge rates are characterized by multiples of the C rate. The C rates associated with the standard-overnight, 1-hour, and 15-minute charge rates are 0.1C, 1C, and 4C, respectively. The C rate essentially defines the amount of current that you apply for a theoretical amount of time to fully charge a battery.

In practice however, these theoretical charge times are simply that. Not all of the energy you supply to charge the battery is converted to a usable form. Many factors, including the C rate, influence the efficiency of the charging process.

Battery as pressure vessel

As you increase the C rate, the charging efficiency increases. However, the internal pressure and temperature of any battery—not just fast-charge ones—also increase as the charge rate increases (**Fig 1**). If the pressure increases too rapidly and by too much, the battery will vent: It will open up to release the excess pressure and in the process disperse some of its electrolyte. Continued venting reduces the lifetime of a battery and, in extreme cases, can destroy it. Thus, manufacturers design fast-charge batteries with rapid-gas-recombination features to prevent inordinate pressure buildup during fast charge.

The basic feature that facilitates faster gas recombination is a large negative electrode, although the internal designs of batteries from different manufacturers vary. The greater the surface area of the electrode, the faster the recombination.
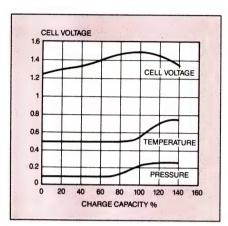
Fig 1—As a battery approaches 100% capacity, its internal pressure and temperature also increase; the slope of these curves steepen as you increase the charge rate. Fast-charge batteries can handle fast-charge rates until they're fully charged, but not into overcharge.

However, a larger electrode requires larger separator and substrate areas and adds no capacity to the cell. Thus, fast-charge cells tend to have somewhat smaller capacities than cells of the same size designed for overnight charge regimes. The lower capacities of fast-charge cells are not only influenced by their internal designs but also by the charge rate itself. You'll typically see more than one capacity rating on fast-charge-battery data sheets: one for the 1- to 1½-hour charge and one for the 4- to 5-hour charge. As a general rule, the capacity of 1-hour-charged batteries is approximately 90% of the battery's rating at the 0.2C charge rate. Make sure you base your battery selection on the capacity rating for your desired charge rate.

Respect overcharge restrictions

Although fast-charge batteries can handle high charge rates during charge, continuing that high rate after the battery reaches nearly 100% capacity can cause serious problems. Fast charging generates internal gases too rapidly to continue into overcharge without venting. The term "overcharge" doesn't imply an adverse condition; it simply refers to the continued application of current after a battery reaches its maximum charge. All NiCd batteries are designed to handle continuous overcharge at some specified rate, but none can withstand overcharging at fast-charge rates.

Thus—regardless of their unique internal designs—fast-charge batteries require controlled charging methods to prevent battery failure and enhance the batteries' performance and service life. Because of the

The GEMAX 4/5 Cs fast-charge cell from Gates Energy Products has a rated capacity of 1050 mAhr at the 1-hour charge rate and a typical internal resistance of 15 mΩ.

Fast-charge systems require tradeoffs
between charge time on the one hand
and cost, battery capacity, and charging-
circuit complexity on the other.

unique requirements of fast-charge systems, Gates and other manufacturers take great pains to prevent misuse of these batteries by not selling the battery until you first consult with its application engineers. The company wants to ensure that you're aware of fast-charging constraints and of the various control approaches.
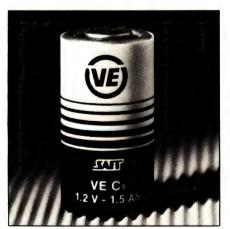
The cylindrical NiCd battery illustrates both the fast-charging constraints imposed by temperature and pressure and the control methods appropriate for fast-charge systems. You can extend the basic principles to other battery types as well. There are basically two things you need to know about sealed, cylindrical battery construction to understand the effects of temperature and pressure during charging. The first is that the separator—the material that separates the positive and negative electrodes—is made of plastic, typically polypropylene. In high-temperature batteries, manufacturers replace the plastic separator with Teflon. The second vital feature is the safety vent. In sealed batteries, this vent releases excessive internal gas pressure.

The separator and safety vent play primary roles in battery function and life. The longer a battery is exposed to high temperatures, the shorter its lifetime because the separator begins to break down. The safety vent prevents catastrophic battery failures—the loss of electrolyte as the battery vents—as long as you don't exceed overcharge-current ratings and maximum charge-current limits or attempt to charge a NiCd battery below the recommended minimum temperature.

Problems with heat or pressure rarely arise if you charge batteries at the 0.1C rate. To charge a NiCd

Table 1—Representative charge rates and NiCd-battery charging methods

Charge time	C rate	Charge-control method	Comments
Standard 10 to 16 hours	0.1C to 0.2C	Uncontrolled constant current	Low cost, simple charger.
Quick 3 to 5 hours	~0.33C	Uncontrolled constant current	Low cost, simple charger.
		Timer control	Increases battery life.
Fast 1 to 1.5 hours	1C	Timer control	Not recommended, depends on battery's discharge state.
		Temperature cutoff	Common method, moderate cost.
		Voltage cutoff	Not recommended, battery's absolute voltage varies with temperature and age.
		Negative delta voltage	Highly recommended, allows close to full-charge capability, requires more complex charging circuit.
Ultrafast ≤1 hour	2C, 4C	Negative delta voltage	Only recommended charge-control method.

battery at the 0.1C rate, apply a constant current equal to one tenth of the battery's rated capacity for 16 to 20 hours. As you increase the C rate, however, you must closely monitor and tightly control certain charge parameters. Depending on the desired charge time and battery

Make sure to distinguish between a battery's capacity rating at standard charge rates versus its rating at high-charge rates. Saft's Cs cell ($1.80 to $2) has a 1.5-Ahr rating at standard rates and a 1.26-Ahr rating at the 1C charge rate.

conditions before charging, you can monitor a variety of conditions including time, temperature, and battery voltage. The various control methods have their own advantages and disadvantages, as shown in **Table 1**.

A charging circuit based solely upon elapsed time applies a certain amount of current to the battery and then reduces the amount of charge current after a prescribed amount of time elapses (**Fig 2a**). For example, a split-rate timer may charge at 0.33C for three hours and then drop the level to 0.1C. For 3-to 5-hour charge rates, the timer technique can extend battery life over uncontrolled constant-current charging. But battery manufacturers don't recommend this method for fast charging because it involves too many unknowns, one of which is the battery's discharge state. Most users don't completely deplete the battery between charge cycles. Thus, using time as the only charge

These quick-charge batteries from Tadiran have capacity ratings for both 2- and 5-hour charge times. The 2-hour charge-capacity ratings for the ½D ($4.75 (1000)) and F ($11.79 (1000)) batteries are 2 and 6.7 Ahr, respectively.

Fig 2—Of the various approaches to fast-charge control, temperature cutoff (c) and the −ΔV circuit (d) are the most highly recommended. Timer- (a) and voltage- (b) cutoff methods depend on too many variables. (Figure courtesy International Components Corp)

control may result in dangerously overcharging the battery.

A charging method that does rely on the state of the battery is voltage cutoff. A charger using this method applies a constant current and monitors the battery's voltage. The charger decreases the applied current when the battery reaches its rated voltage (Fig 2b). Battery and charger manufacturers generally don't recommend this method either because safely achieving full charge based solely on the battery's absolute voltage is difficult. First of all, the final voltage of a cell varies as the temperature varies. Thus, this method requires some sort of temperature compensation. Also, a cell's voltage setpoint changes throughout the lifetime of the cell. And if one cell of a multicell battery pack drops out for any reason, the charger will continue to apply current, thereby severely overcharg-

ing the working cells.

Probably the most widely used and most reliable charging method for charging times as short as one hour at the 1C rate is temperature cutoff. This method relies on the fact that a NiCd battery's temperature rises as the battery approaches its full charge state (Fig 2c). A thermal sensor located on or near the battery indicates when a particular temperature is exceeded, and then shuts off or lowers the level of the constant-current source. You can design such a system by placing a thermostat near the battery; many manufacturers offer bat-

tery packs with thermal switches built in.

Precise control senses peak

Other than the fact that it requires an additional thermal component, there are few disadvantages to the temperature-cutoff method for 1- to 2-hour charge systems. However, this method's major limitation is its response time. For truly fast charge systems—those with charge times under 1 hour and as fast as 15 minutes—battery manufacturers unanimously agree on the negative-delta-voltage (−ΔV), or negative-slope-cutoff, circuit. Many

manufacturers recommend this method even for 1- to 1½-hour charging.

When a NiCd battery reaches full charge, there is a slight dip in its voltage characteristics (**Fig 2d**). The $-\Delta V$ circuit senses the differential between the peak voltage and some lower voltage level. The $-\Delta V$ technique doesn't require any additional components, nor does it require compensation for the temperature or age of the battery because it senses only relative voltages. The technique's major advantage is that it always lets you safely fast-charge a battery to very near its full capacity. The technique's major disadvantages are the complexity of the control circuit and the size of the power circuit. Adding to the design difficulty is the fact that the effectiveness of the control circuit depends on the battery's exhibiting a reliable and repeatable voltage profile.

There are many possible implementations of the $-\Delta V$ circuit. Panasonic includes a general diagram of a simple analog circuit in its NiCd batteries technical handbook (**Fig 3**). In **Fig 3**, the capacitor is the hold element. When the two IC inputs differ by a certain negative voltage, the output triggers, thus causing the current controller to decrease the power supply's input to the battery. Typical designs detect a negative voltage drop of around -10 mV/cell at 20°C. A word of caution: Don't let the apparent simplicity of the circuit in **Fig 3** lead you to underestimate the design challenge of a $-\Delta V$ circuit.

You can also perform voltage sensing digitally. International Components Corp (ICC) holds the patent on its $-\Delta V$ design, which uses RAM to store past values of a battery's voltage. A major part

Fig 3—Many approaches exist to implement a $-\Delta V$ control circuit. This general analog circuit uses a capacitor to store the battery voltage, which the IC compares to the present level. A variety of digital approaches using µPs and RAM are also popular. (Figure courtesy Panasonic Industrial Co)

of ICC's business is to work with engineers to develop charge systems, but it licenses its charger design and chips to users. ICC also offers board-level products: A typical 6-cell, sub-C, 15-minute charger on a pc board costs about $20 in OEM quantities.

Of course, you can develop your own voltage-sensing circuit, but you'll probably want to clear your circuit's specification with the battery manufacturer. A short list

highlights only some of the design aspects you'll have to specify:

- voltage-sensing scheme: analog or digital
- differential voltage trip point
- speed of circuit control and feedback
- current-switch requirements
- power-source output capability.

Most companies recommend that you combine two techniques to increase your system's reliability. For example, **Fig 3** shows a timer block, which shuts off the charge after a certain amount of time to protect the battery in the case of control- and sensing-circuitry failure. Other backup options include using a temperature switch or thermal fuse. Also, the most effective control circuits don't implement on/off control. Most battery manufacturers recommend that you use split- or dual-rate chargers, which lower the charge rate to some acceptable level once the battery reaches full charge.

The final option, of course, is to buy a completely designed charger. Eveready recently announced fast-charge batteries and companion

The Cadnica family of cylindrical fast-charge batteries range in capacity from 450 to 4000 mAhr rated at 0.2C. They range in internal resistance from 9 to 2.8 mΩ. Sanyo recommends the $-\Delta V$ charging method for 1-hour charge rates.

chargers aimed mostly at the consumer marketplace. The Generator system charges Generator AA, C, and D batteries in 1 hour using a unique implementation of the $-\Delta V$ method with a timer backup circuit. The charger is available in two sizes. A compact charger ($39.99), which measures $2.75 \times 2.375 \times 5.25$ in., charges four AA Generator batteries simultaneously. A larger model ($49.99), which measures $3.625 \times 2.125 \times 10.75$ in., simultaneously charges any combination of four AA-, C-, or D-size Generator batteries. The C- and D-size batteries cost between $7.99 and $9.99 a pair. The AA four pack costs $13.99.

Alexander Battery manufactures NiCd-battery chargers in addition to a wide variety of battery packs. Its single-unit SM12000 ($105), 3-unit SM32000 ($310), and 6-unit SM62000 ($375) Smart Chargers fully charge NiCd battery packs whose voltages range from 6 to 15 V at a 425-mA rate. These units can fully charge a 500-mAhr battery in approximately 1½ hours; a 9-mAhr trickle charge keeps the battery fully charged until you're ready to use it. The internal control circuit is based on a patent-pending, microprocessor-based $-\Delta V$ circuit.

NiCd-battery chargers are also available from Ault Inc. Its smart chargers use a combination of temperature and voltage sensing to charge 3 to 24V batteries. A thermistor implements the primary control by switching the charger from fast to float charge when the battery temperature reaches its threshold. The output-voltage sense—which you can program to different levels—limits the battery's peak voltage during the charge cycle.

Exceptions to the rule

All of the circuits and chargers discussed so far are designed for NiCd batteries. In contrast to the constant-current charging regime for NiCd batteries, the most common method of charging sealed lead-acid batteries is constant-voltage charging. However, you can also charge lead-acid batteries with constant-current and combined current and voltage charging methods. As with NiCd batteries, overcharge currents for lead-acid batteries must be less than some acceptable level.

Unfortunately, the rules for fast charging lead-acid batteries aren't particularly clear cut. The charge regimes for lead-acid batteries seem a little more variable and manufacturer dependent. Thus, you may need to consult extensively with the battery manufacturer to safely fast-charge its batteries. Gates' lead-acid batteries have a unique construction that enables them to accept high charge currents without the water loss that curtails the life of other lead batteries. Gates claims that you can charge its batteries to 80 or 90% of capacity in less than an hour using a constant-voltage charger set at the proper voltage.

In addition to battery chemistry, battery packaging also affects the charging method. Cylindrical batteries are the most common package. Button cells are popular for backup power and rarely need fast

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For more information . . .

For more information on the rechargeable batteries and charging circuits such as those described in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Alexander Batteries
Box 1508
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(800) 247-1821
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Circle No. 650

Ault Inc
7300 Boone Ave N
Minneapolis, MN 55428
(612) 493-1900
FAX 612-493-1911
Circle No. 651

Eveready Battery Co
Checkerboard Square
St Louis, MO 63164
(314) 982-2000
Circle No. 652

Gates Energy Products
Box 114
Gainesville, FL 32602
(904) 462-3911
FAX 904-462-4726
Circle No. 653

International Components Corp
420 N May St
Chicago, IL 60622
(312) 829-2525
FAX 312-829-0213
Circle No. 654

Ovonic Battery Co
1826 Northwood Dr
Troy, MI 48084
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FAX 313-362-0332
Circle No. 655

Panasonic Industrial Co
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Secaucus, NJ 07094
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Saft America Inc
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FAX 912-247-7780
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Sanyo Energy Corp
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San Diego, CA 92073
(619) 661-6620
FAX 619-661-2122
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charging. The latest package style is the rectangular "gum" pack. Rectangular packs are relatively new and are not particularly amenable to handling high pressure, thus few fast-charge options exist. Nevertheless, Sanyo's Cadnica slim-pack rectangular NiCd battery does feature a 1-hour charge rate. The Cadnica KF-A600 ($6.44 (100)) has a 600-mAhr rating at a 0.2C rate, which translates into about 540 mAhr at the 1C rate.

Whichever charge method or battery type you choose, you'll want to get the most out of the battery while maintaining safety. Considering charge criteria early in a product's development forces you to face reality about what a fast-charge battery can and can't do on its own.

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Reference
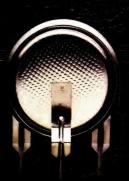
1. *Sealed Rechargeable Batteries Application Manual*, Gates Energy Products.

Acknowledgment

Many thanks to ICC for its valuable information on charging constraints and control circuits.

**Article Interest Quotient
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When *Popular Science* reviewed new power tools, many were good. In fact, even great. But one of them stood out above all the others. The Porter-Cable Model 9850. A professional cordless driver/drill—driven to perfection by a rechargeable battery from Gates Energy Products.

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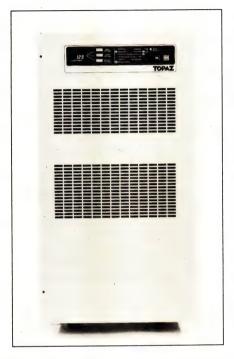
Uninterruptible power supply operates in on-line and standby modes

Available in 3-, 5-, and 10-kVA models, the Powermaker Mini UPS (uninterruptible power supply) can operate in both on-line and standby modes. In the on-line mode, the Mini completely isolates systems from the ac line to provide maximum protection. In standby, the unit has a 4-msec transfer time.

The Powermaker Mini is available with input and output voltages of 120, 208, 220, 230, or 240V ac. Users can select any combination of these values on site, so one power supply can satisfy applications anywhere in the world.

The UPS employs advanced insulated-gate bipolar-transistor PWM technology, which provides clean sine-wave power and a 300% overload capability for demanding loads.

The supply features a common-mode noise attenuation of 100 dB and a normal-mode attenuation of 48 dB.

Sealed lead-acid rechargeable batteries provide a minimum of 10 minutes of backup power for all power configurations and 15 minutes of backup for the 3-kVA model. The batteries are located in two slide-out trays within the unit. This arrangement makes it easy to install, service, or replace the batteries from the front of the unit. The Powermaker Mini UPS costs $6150 to $14,900; delivery is stock to eight weeks ARO.

Square D Co, Power Protection Systems, 9192 Topaz Way, San Diego, CA 92123. Phone (619) 279-0111. **Circle No. 700**

Board-mountable dc/dc converters meet military design requirements

All units in the AHE2800 Series of pc-board-mountable dc/dc converters meet the requirements of MIL-STD-740D. Models in the line have single or dual outputs with 15, 20, or 30W output-power capabilities.

All converters in the AHE2800 Series have a nominal input of 28V but can handle inputs of 17 to 40V. The AHE2805 has a 5V output. The 2812 has a 12 or ±12V output; the 2815 has a 15 or ±15V output. The circuit design incorporates a pulse-width-modulated push-pull topology, which operates in the feed-forward mode at a nominal switching frequency of 250 kHz to deliver a power density of 17W/in³. Transformers in the forward and feedback circuits supply input-to-output isolation.

The AHE2800 Series converters are available in three temperature-range grades: −55 to +85°C, −55 to +105°C, and −55 to +125°C. Full military screening to MIL-STD-883C, Method 5008 is available. Efficiency ratings range from 78 to 84%. The converters feature indefinite short-circuit and overload protection and a pin that allows for shutdown via an external signal. Line and load regulation is ±0.5% typ in all three temperature ranges. Maximum ripple is 60 mV p-p.

These dc/dc converters are available in a plug-in package for pc-board mounting and in a flanged package to accommodate more severe environments. An optional EMI filter reduces the input ripple current to levels below the limits imposed by Condition CEO3 of MIL-STD-461B. The −55 to +85°C converters cost $299 to $320 (100).

Advanced Analog, 2270 Martin Ave, Santa Clara, CA 95050. Phone (408) 988-4930. FAX 408-988-2702. **Circle No. 701**

Power Sources

Multiple output supplies operate with ac or dc inputs

Housed in the industry-standard 5×8-in. case, BB Series power supplies accept 115 or 230V ac or 48V dc inputs from an externally connected, sealed lead-acid battery. When the supplies are operating from the ac line, an internal circuit charges the battery at a nominal 56V. When ac failures occur, the battery provides energy through a switching up-converter to keep the main converter operational. The supplies have control and monitor features to ensure proper power transfer.

BB Series supplies feature as many as four outputs with voltages of 2 to 48V. Their maximum power capability is 750W. All outputs are electrically isolated and can be connected for either positive or nega-

tive output polarities. Line regulation is 0.2%; load regulation is 0.2 to 5%. Ripple and noise are 50 mV on the main output and 75 mV on the auxiliary outputs.

In addition to the backup capability, BB Series supplies incorporate a number of system interface features that enable the host system to control and monitor power-supply operation. These features in-

clude remote inhibit, remote margining of the main output, ac-power fault detection, overvoltage fault detection, and out-of-tolerance detection of the main output. Other standard features include no-load protection, overload protection, thermal protection, an input-line filter, inrush-current limiting, and soft start. A current-sharing feature is also available.
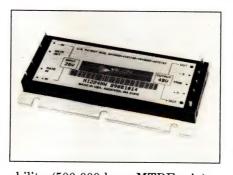
The units in the BB Series are recognized by UL, are approved by CSA, comply with VDE safety standards, and cost $1470.

Unipower Corp, 2981 Gateway Dr, Pompano Beach, FL 33069. Phone (305) 974-2442. FAX 305-971-1837. **Circle No. 702**

Wide-input dc/dc converters comply with MIL-STD-704D requirements

MI Series dc/dc converters operate from nominal inputs of either 28 or 270V. The 28V-input models (MI-220s) are rated for continuous operation over a range of 18 to 50V; the 270V units (MI-260s) have a 125 to 400V input rating. Both input ranges exceed the MIL-STD-704D input-transient-envelope operating requirements. In addition, the converters are fully protected from undervoltage conditions of any duration.

The design of the converters in the MI Series is based on the company's zero-current switching topology. This topology offers state-of-the-art performance in terms of power density (23W/in.^{3}), efficiency (85%), noise (3% p-p max) and reli-

ability (500,000-hour MTBF min).

Standard output voltages of 5, 12, 15, 28, and 48V are available in the MI Series. Output power levels are 50, 75, and 100W for each input. Power boosters are available to satisfy higher power requirements. You can externally trim or program all units from 0 to 110% of their output-voltage ratings. Overvolt-

age protection, overtemperature protection, current limiting, remote sense, and inhibit are all standard converter features.

The converters are conduction-cooled and are rated for full-load operation over a base-plate temperature range of −55 to +85°C. Stringent environmental-stress screening, MIL-STD-810 environmental compliance, and MIL-I-45208 quality standards let the converters satisfy a wide variety of military applications. MI Series converters cost $540 to $680; delivery is stock to 10 weeks ARO.

Vicor Corp, 23 Frontage Rd, Andover, MA 01810. Phone (508) 470-2900. FAX 508-475-6715.

Circle No. 703

Power Sources

Triple-output switchers handle power-sharing applications

The MPS453-0512 triple-output 450W switching power supply is designed for critical applications that require parallel power sharing, redundant power supplies, or expandable systems. The unit utilizes the company's zero-wire power-sharing system to provide a parallel, highly reliable system.

Although typical parallel systems use expensive and complex single-wire power techniques, the MPS453-0512 switchers use droop-regulator technology. This technology ensures that the parallel switcher always delivers some current and thereby provides an optimum power-sharing system. Any number of switchers can be built

into a system to allow paralleling for additional power or N + 1 redundancy. You can also use the supply as a building block for future system expansion.

The MPS453-0512 delivers 450W with a main output of 5V at 60A. The unit also has an output of 12V

at 10A and an auxiliary output of −12V at 6A. It is housed in a low-profile, open-frame package measuring only 11.5×5×2.5 in. Other features include overvoltage, over-temperature, and overcurrent protection; soft start; and remote inhibit. AC power fail is also available.

The MPS453-0512 switcher meets UL, CSA, and TUV requirements. It costs $446 (100), and delivery is six weeks ARO.

Todd Products Corp, 50 Emjay Blvd, Brentwood, NY 11717. Phone (516) 231-3366. TWX 510-227-4905. Circle No. 704

Encapsulated dc/dc converters accommodate low-power applications

These dc/dc converters, models 24S12.3500UW and 24S15.3000-UW, output 12V at 3.5A and 15V at 3A, respectively. Both accept inputs of 14 to 40V. The units were designed for use in telecommunications and battery-operated equipment. Since the output can be digitally programmed ±10% using a simple D/A converter, the units are also suited for automatic-test-equipment applications.

A remote-sensing capability lets both converters maintain output regulation over the full output range. You can turn off the converters using a logic signal to minimize converter power consumption.

Key specifications for the 24S12.3500UW and 24S15.3000UW
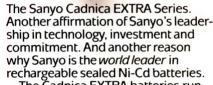
include 0.02% line and load regulation, short-term stability of 0.04%/24 hours, 120-μsec transient response, 20-mV noise, 90% efficiency, and a 100-kHz switching frequency. The converters can withstand short-circuit conditions for at least eight hours, and they operate

over a −25 to +80°C range.

Built-in transient suppressors guard the input and output of both converters against high-voltage spikes. Internal thermal shutdown circuitry provides overtemperature protection for the units; an undervoltage lockout circuit prevents damage during brownout conditions. Low-radiation pot cores, toroidal inductors, and a 6-sided shielded case minimize converter RFI problems. The 24S15.3000UW and the 24S12.3500UW both cost $130.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911. FAX 415-932-6017. Circle No. 705

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CIRCLE NO 149

Power Sources

Triple-Output DC/DC Converters

UWT Series triple-output dc/dc converters develop a 100W output and operate at 82% efficiency. The units operate from inputs of 18 to 36V or 36 to 72V, and they output 5 and ±12 or ±15V. The converters feature a 100-kHz switching frequency. Voltage accuracy is better than 1%, and ripple and noise equals 100 mV p-p. Additional standard features include reverse-voltage, short-circuit, and overvoltage protection; remote sensing; and thermal shutdown. UWT Series converters are housed in 6-sided shielded cases to reduce noise-radiation problems. $200 (100).

International Power Devices, 155 N Beacon St, Brighton, MA 02135. Phone (617) 782-3331. FAX 617-782-7416   Circle No. 384

Single- Or Dual-Output DC/DC Converters

Available with either single or dual outputs, these dc/dc converters have outputs of 10W for the 9010 Series and 20W for the 9020 Series. Featuring power densities of 2.5 and 5W/in^3, respectively, the converters operate on inputs of 18 to 32V and have output levels ranging from 5 to 24V.

Efficiency figures for the converters measure 70% min, and switching frequency equals 350 kHz. Isolation equals 100V between input and output and between input/output and case.

The 9010/9020 converters feature overvoltage protection as standard and operate over a −55 to +100°C range. $695 to $805 (100). Delivery, 14 weeks ARO.

Tecnetics Inc, Box 910, Boulder, CO 80306. Phone (303) 442-3837. TWX 910-940-3246.

    Circle No. 385

DC/DC Converters

Available with either single or dual outputs, these dc/dc converters have outputs of 10W for the 9010 Series and 20W for the 9020 Series. Featuring power densities of 2.5 and 5W/in.^{3}, respectively, the converters operate on inputs of 18 to 32V and output levels ranging from 5 to 24V. Efficiencies equal 70% min, and the switching frequency measures 350 kHz. Isolation equals 100V between input and output and between input/output and case. The converters feature overvoltage protection as standard and operate over a −55 to +100°C range. $695 to $805 (100). Delivery, 26 weeks ARO.

Tecnetics Inc, Box 910, Boulder, CO 80306. Phone (303) 442-3837. TWX 910-940-3246.   Circle No 386

External Power Supplies

The WRI Series of external power supplies includes 16 models that have output power capabilities as high as 52W. Capable of operating from any standard worldwide input source, the supplies are prequalified to the Level B noise-emission

standards of FCC and VDE. In addition, all units are safety-approved by UL, CSA, IEC, and TUV.

The WRI line includes five 25W models, four 30W units, five 42W models, and two 52W units. All are available in single-, dual-, and triple-output versions, and all outputs are fully regulated. Input-voltage ranges are 90 to 264V ac at 47 to 440 Hz, or 120 to 350V dc. A broad variety of output cables and connectors—5-pin DIN, 9-pin Sub-D, 15-pin Sub D, 4- and 6-pin Molex, among others—may be specified as interchangeable options without affecting international safety approvals. Input connection to the supplies is made via an IEC connector. $74 (100).

Elpac Power Systems, 3131 S Standard Ave, Santa Ana, CA 92705. Phone (714) 979-4440. FAX 714-241-7293.   Circle No. 387

Compact DC/DC Converter

Housed in a package measuring $5 \times 3 \times 0.5$ in., this dc/dc converter accepts 36 to 72V inputs and delivers a 5V at 40A output—a power density of 27 W/in^3. Available in assembled or kit versions, the unit owes its small size to the use of planar magnetics. The converter has an 80% efficiency at full load and features a total regulation of 1%.

The converter features short-circuit protection, current-mode PWM control, 50-mV output ripple, soft start, no minimum load requirement, and 500V input-to-output isolation.

All power components are thermally referenced to one base plate/heat sink. This aluminum base plate can be conduction or forced-air cooled. Converter kits include instructions, parts list, schematic, and troubleshooting manual. Kit, $250; assembled version, $500.

Multisource Technology Corp, 393 Totten Pond Rd, Waltham, MA 02154. Phone (617) 890-1787. FAX 617-890-8011. Circle No. 388

2000W Switching Supply

The JF201 is available in single- and 3-phase versions, both of which accept 220V ac and 300V dc inputs and provide 2 or 5V dc outputs at 400A. Other standard outputs include 12, 15, 24, 28, and 48V dc.

For loads in excess of 90%, the JF201 features a power factor as high as 0.95. The supply has an 80% efficiency at full-rated load and operates over a 0 to 50°C range. The 3-phase versions include phase-loss protection enabling them to deliver full power if one phase is lost at the input. To promote load sharing, the supply uses a single-wire paralleling architecture that provides a 2% share accuracy for units operating above 10% of rated load. Overload and thermal protection are standard. Single-phase models have UL, CSA, and IEC 380/VDE 0806 certification. From $1400.

ACDC Electronics, 401 Jones Rd, Oceanside, CA 92054. Phone (619) 757-1880. Circle No. 389

Open-Frame Power Supplies

TMA Series open-frame power supplies offer from one to four outputs and have a total power-output capability of 175 to 400W. The 30 models in the series are available in eight basic footprint designs, depending on output requirements. Models in the TMA Series operate from 115 and 230V ac single-phase inputs and provide outputs of 4, 5, or 9A at

THERE'S A NEW POWER BEHIND TODAY'S COMPUTERS AND ELECTRONIC SYSTEMS.

COMPUTER PRODUCTS INTRODUCES THE NEW NFS200.

90 to 264 VAC UNIVERSAL INPUT OPEN-FRAME SWITCHERS
FOR THE WIDE RANGE OF INTERNATIONAL POWER APPLICATIONS.

Imagine. A power supply you can plug in anywhere in the world:

Power for your PC-based systems, modems, disk drives, mass storage, VME systems, medical or instrumentation ...

The only commercial switcher with four outputs delivering up to 200 watts using continuous, universal input (90-264 VAC, 47-63 Hz). No more external cable and 115/220 switches. No more failures from the wrong input voltage.

The secret is our exclusive, patent-pending "clipper" circuit, which slows current rise time and limits upper switch transistor voltage without wasting power. (Other switchers — if they offer universal input at all — use expensive, space-grabbing "autostrap" circuits.)

All this, from a compact 9″ x 5″ x 2½″ package — a power density of over 1.7 watts/in³ — at a price well below any competitor.

And for your convenience, we've included a +12V fan outlet.

Of course, NFS200 is completely approved by UL, CSA and VDE; and reduces line conducted noise below FCC and VDE limit A.

NFS200 is the newest in our extensive line of universal input switchers, ranging from 25 to 600 watts. It's a natural addition to our growing family of both AC/DC and DC/DC power supplies. Computer Products. Now, more than ever *the power behind the products.*

MODEL	WATTS	W/AIR	NUMBER OF OUTPUTS
NFS25	25	25	1 Dual, 2 Triples
NFS40	40	50	4 Singles, 4 Triples
NFS42	40	40	3 Triples
NFS50	50	60	1 Triple
NFS110	80	110	4 Singles, 3 Quads
NFS200	—	200	1 Triple, 3 Quads
NFS350	—	350	1 Triple, 2 Quads
*NFS600	—	600	1 Triple, 3 Quads

*To Be Announced

If Reply Card Is Missing Use Reader Service Number.

COMPUTER PRODUCTS ®
POWER CONVERSION

Computer Products, Inc./Power Conversion/3785 Spinnaker Court, Fremont, CA 94538

Glassman
HV supplies like to be compared!

14"
19"
140 lbs.
3 KW

10.5"
19"
70 lbs.
4 KW

All Glassman HV supplies are better by design, offering a combination of performance, size, and weight that beats the competition hands-down. Consider the new PK Series...

Nearest Competitor	PK Series
3 KW, 14" high	4 KW, 10.5" high
0.63 W/in.³	1.2 W/in.³
21.4 W/lb.	61.5 W/lb.
140 lbs.	70 lbs.

But numbers are not the whole story. For example, only the PK Series shows you at a glance its complete status. Indicators signal power on, HV on, standby, safety interlock, external trip, polarity, remote/local control, regulating mode (voltage or current), output voltage and current...even a bargraph trend indicator for pulsed load applications is standard.

Glassman's pulse width modulated circuitry delivers regulation better than 0.01%, low ripple, fast transient response, and full load efficiency greater than 85%... all with lower parts count for greater reliability. And Glassman's unique air insulation offers field-proven serviceability while it contributes to reduced weight.

Call or write for full information. Compare the PK Series to any others...we're confident you will decide that Glassman is the true innovator in high voltage power supply technology.

Glassman High Voltage, Inc.

Route 22 (East)
Salem Industrial Park, PO Box 551
Whitehouse Station, NJ 08889
Telephone (201) 534-9007
TWX 710-480-2839
FAX: (201) 534-5672

GLASSMAN HIGH VOLTAGE INC.

CIRCLE NO 153

Power Sources

voltages of 5 to 48V. Line regulation equals 0.1% over the entire input range for all models; load-regulation figures range from 0.4 to 4.4%.

The supplies meet FCC and VDE emission specifications as well as UL, CSA, VDE, and IEC safety standards. Protection against input line transients is standard. Available options include autoranging, overvoltage protection, margining on the main output, fail signals, current sharing, dc OK signals, and remote power on/off. $200 to $270.

LH Research Inc, 14402 Franklin Ave, Tustin, CA 92680. Phone (800) 547-2537. **Circle No. 390**

High-Density DC/DC Converters

Housed in a 0.98×3.4×4.85-in. module, RO Series dual-output dc/dc converters produce a full-power

output of 125 to 150W at 20°C ambient with no heat sink or fan required. The converters operate from 36 to 66V (RO 48 Series) or 200 to 400V (RO 300 Series) and generate outputs of 5V at 25A, 12V at 12A, 15V at 10A, 24V at 6A, or 28V at 5A. Input overvoltage protection equals 100V max for RO 48 units and 450V for RO 300 models.

The RO Series provides true N+1 redundancy with current-sharing, paralleling, and hot plug-in capabilities. Nonshutdown overvoltage protection, logic on/off, short-circuit protection, and

overtemperature protection are all standard. The converters in the RO Series comply with MIL 810D, UL, CSA, and VDE requirements. In addition, they feature constant-frequency operation, which eliminates any beat-frequency problems. $249. Delivery, stock to 60 days ARO.
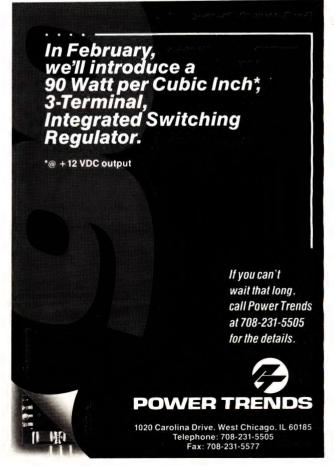
RO Associates Inc, 246 Caspian Dr, Sunnyvale, CA 94088. Phone (408) 744-1450. FAX 408-744-1521. **Circle No. 391**
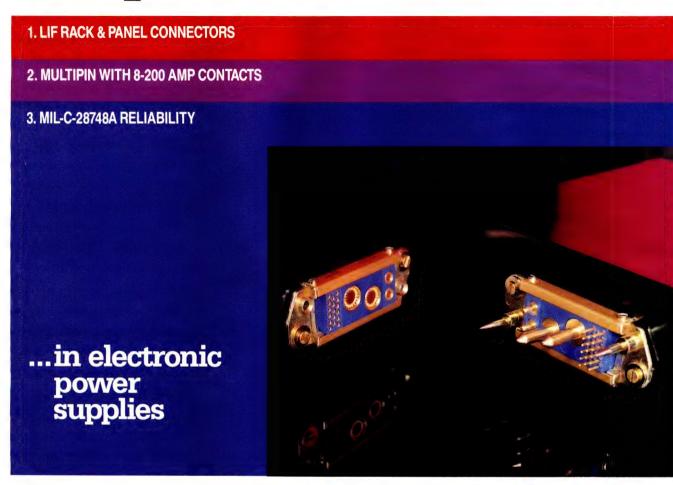
Single-Output Switching Power Supplies

Offering a total power-output capability of 75W, the SM55 Series includes four single-output switching power supplies that generate outputs of 5V at 15A, 12 or 15V at 6.2 or 5A, 24V at 3.1A, and 48V at 1.5A. An optional daughter-board assembly, which contains an active preload circuit, allows the supplies

Power Sources

to maintain full regulation at load levels as low as zero. This preload circuit automatically switches out at higher loads to maintain efficiency figures.

Standard features of the SM55 supplies include power-fail detect with dual-polarity TTL compatibility, external inhibit, overload and
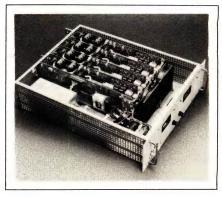
short-circuit protection, latching overvoltage protection, and remote sensing on the 5 and 12V models. Line-conducted noise is filtered to

the required level for VDE 0871 curve B compatibility over the full bandwidth of 10 kHz to 30 MHz. SM55 supplies meet the safety requirements of UL 478, CSA 22.2, VDE 0806, and IEC 950. The units'packages are suitable for mounting in 3U racks. $143.50 (10). Delivery four to six weeks ARO.

Weir Electronics Inc, 418 3rd St, Annapolis, MD 21403. Phone (301) 268-0122. **Circle No. 392**

High-Voltage Supply

Model 25020 provides an output of 0 to 250V dc at 0 to 20A. Housed in a rack-mount chassis, the supply features a design that employs field-replaceable modules for ease of maintenance and repair. Each module operates independently, so loss of an individual module does not disrupt the performance of the remaining modules.

Performance specifications of the Model 25020 include a voltage and current regulation of 0.1% of maximum output and an operating range of 0 to 50°C. The supply can operate in series or parallel, master or slave modes. For fixed line, load, and temperature, the output will stay within ±0.05% of setpoint for eight hours. The output will return to within 2% of final value within 10 msec for a 30% step-load change. The Model 25020 comes with re-

CIRCLE NO 160

mote control and programming capability as standard features. $3250. Delivery, six weeks ARO.

Power Ten Inc, 486 Mercury Dr, Sunnyvale, CA 94086. Phone (408) 738-5959. **Circle No. 393**

Single-Output Switchers

NFS40 Series single-output switching power supplies are configured on a $5 \times 3 \times 1.2$-in. open board. The series includes four models—NFS40-7605, which outputs 5V at 8A; NFS40-7612 with an output of 12V at 4A; NFS40-7615 with an output of 15V at 3.3A; and NFS40-7624, which outputs 24V at 2A.

All units will deliver 50W continuous output with forced air cooling or 40W with convection cooling. The supplies will also deliver 60W for short periods of time if you need to actuate a relay or start a hard-disk drive. NFS40 Series supplies have no minimum load requirements. Other pertinent specifications include a holdup time of 12 msec at full output power and a typical efficiency of 70%. Line regulation equals ±0.5%, and MTBF measures 500,000 hours. $43 (1000). Delivery, stock to 16 weeks ARO.
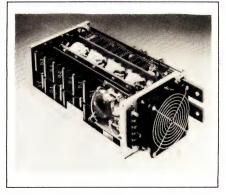
Computer Products Inc, 3797 Spinnaker Ct, Fremont, CA 94538. Phone (415) 657-6700. FAX 415-683-6452. **Circle No. 394**

3-kW Power Supplies

9R Series power supplies provide 3 kW of output power from a package measuring only $5 \times 8 \times 15$ in. Standard models in the series provide outputs of 2, 5, 12, 15, 24, 36, and 48V dc.

Nominal input for the 9R supplies is 220V ac, single phase or three phase. The units can also operate as dc/dc converters, accepting inputs of 200 to 375V dc (19A max). A terminal board provides a termination vehicle for the supply input.

Standard features include current-sharing capability (N + 1 applications), active soft start, dc fan, remote sensing, and automatic thermal shutdown. Available I/O signals include high- or low-logic inhibit, input power fail, output good, remote adjust, current share, and margin high/low. The units meet

500,000hrs.
MTBF

That's **acdc**. Power Supplies built to keep working, and working, and working! Specifically, our 500 to 1500 watt switchers have MTBF numbers that literally just won't quit.

INDUSTRY LEADERSHIP

Reliability is designed in first, and verified during the development of each product. Every unit is manufactured with controlled processes, thoroughly computer tested and burned-in at full load (40^{0}C with 60 second AC cycling for up to 48 hrs.), **acdc** builds supplies like nobody else.

The result is this...exceptionally high MTBF performance demonstrated in the field, setting the new industry standard for reliability.

GREAT FEATURES...
GREAT PRICE!!!

Of course our supplies meet UL, CSA, IEC Safety Specs and can be ordered in any number of output configurations. All this performance for a price you may already be paying for a not-so-reliable brand.
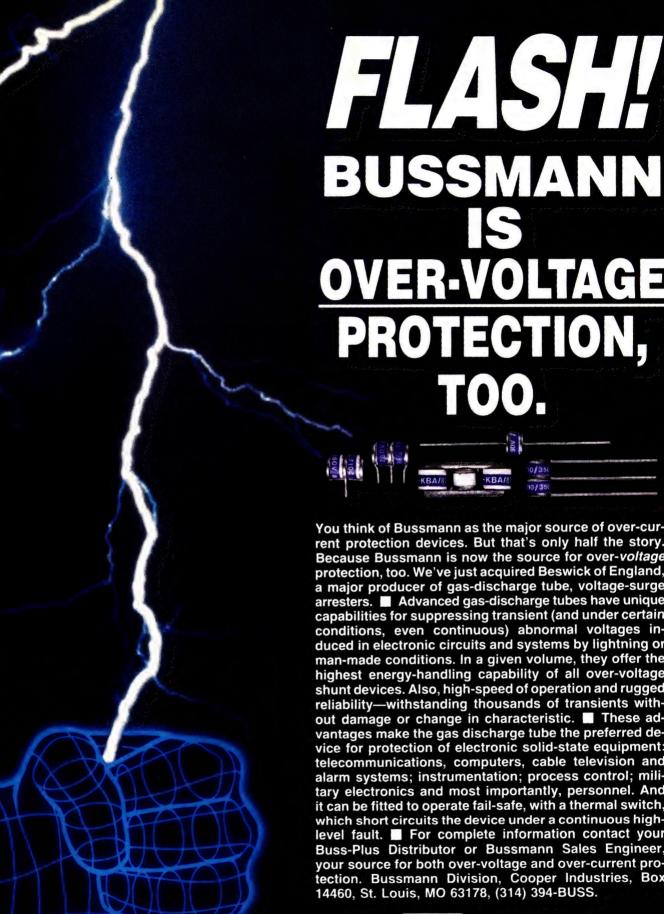
OBSERVED MTBF			
MODELS	**POWER**	**UNITS**	**MTBF (HOURS)**
SINGLE'S			
RSF501	500W	9,000	877,000
JF751	750W	8,000	448,000
JF101	1000W	11,000	403,000
JF151	1500W	3,000	400,000
MULTI'S			
RSF504	500W	8,000	346,000
REV804	800W	10,000	365,000

acdc has maintained a complete database of shipments and returns since 1985. Observed MTBF statistics are calculated per MIL-STD-781.

YOUR POWER SUPPLIER from 15-2000 watts

acdc
electronics ▣

401 JONES ROAD, OCEANSIDE, CA 92054
TEL: 619-439-4200   FAX:619-439-4243

CIRCLE N. 162

Power Sources

UL, CSA, IEC, and VDE specifications. $1890 for the 9R-600-381, a 5V-at-600A model.

Powertec, 20550 Nordhoff St, Chatsworth, CA 91311. Phone (818) 882-0004. FAX 818-998-4225.
Circle No. 395

Isolated AC Power Sources

Models WP-30 and WP-32, at currents of 5 and 10A, respectively, provide an isolated ac output of 0 to 150V. Once you establish voltage and current output levels, a latching relay monitors the source output. Should the output exceed preset levels, the relay will open circuit and reduce voltage and amps to zero.

Both source models include a tester that can measure ac leakage current in equipment in order to verify if the leakage is within limits established by UL and CSA. An audible alarm warns of hot-chassis conditions and of short circuits to exposed metal on the equipment under test. The WP-30 and WP-32 are each supplied with two meters; one monitors voltage, and the other monitors current or leakage. The sources' metal cases are connected to the power lines ground through the ac power cords. The ac inputs are also fused. Model WP-30, $420; WP-32, $570.

Kappa/Viz Test Equipment, 175 Commerce Dr, Fort Washington, PA 19034. Phone (215) 643-6950. FAX 215-643-5237. **Circle No. 396**

Single-Output DC/DC Converters
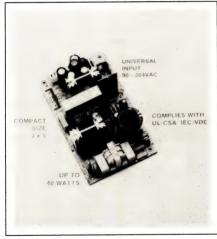
The PSK Series of dc/dc converters includes models that have single outputs of 5, 12, 24, and 36V in 16 and 20A versions. The 5V units are also available in 25A versions. The converters accept inputs of 8 to 80V and have efficiency ratings of 82 to 94%. Line and load regulation for the PSK converters is ±0.3%. Output ripple is <100 mV p-p, and load-

transient recovery time equals 40 μsec for a 33% step-load change.

Standard converter features include remote on/off, adjustable output, input filtering, remote sensing, load-sharing capability, and temperature surveillance. Inrush-current limiting, output thyristor crowbar, and output potentiometer are available as options. PSK converters operate over a −25 to +71°C range. Mechanically, they are compatible with single-height Eurorack or chassis mounting. $300 (100). Delivery, stock to 10 weeks ARO.

Melcher Inc, 200 Butterfield Dr, Ashland, MA 01721. Phone (508) 881-4715. FAX 508-879-8669.
Circle No. 397
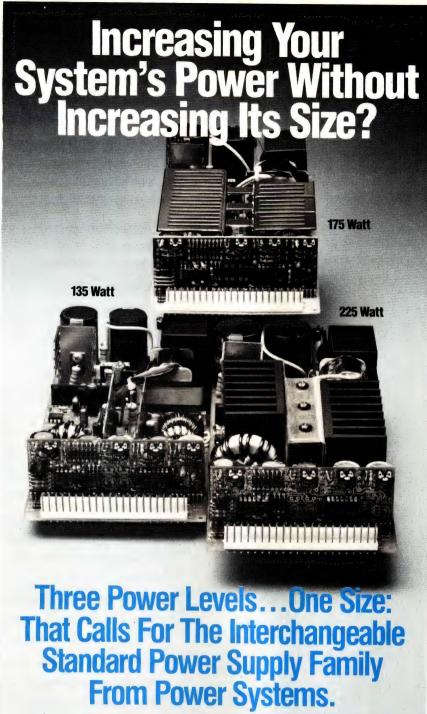
Card Power Supplies

Housed on a 3 × 5-in. card, TPSU40 switching power supplies meet the safety specifications of VDE 0806 and IEC 380. Available models offer single, dual, and triple outputs in combinations of 5, 12, or 15V dc and provide as much as 40W of power. The supplies have a universal input range of 90 to 264V ac.

Line regulation is ±0.2% typ. Load regulation equals 2% for the main output and 5% for auxiliary outputs. Typical noise and ripple measure 1%. Overvoltage and overcurrent protection are standard. TPSU40 supplies have an efficiency figure of 70%. Full-load operating

Sources

range spans 0 to 50°C. The supplies meet with UL and CSA safety regulations, as well as with VDE and FCC EMI limits. From $67. Delivery, eight weeks ARO.

Total Power International Inc, 418 Bridge St, Lowell, MA 01850. Phone (508) 453-7272. FAX 508-453-7395. Circle No. 398

100W DC/DC Converters

DC1000 single- and triple-output dc/dc converters are designed for distributed power applications. The 100W single-output units feature 5, 12, or 15V outputs, while the triple-output units feature 5 and ±12 or ±15V outputs. Output capacity for the auxiliary outputs equals 2A.

Two input voltage ranges are available—18 to 36V and 36 to 72V. Single-output converters have line and load regulation of ±1%, and tri-

ple-output units have ±2% line/load figures for the auxiliary outputs. Maximum ripple and noise are 1 and 2%, respectively. Efficiency for the DC1000 converters equals 82% typ. All models operate over a −20 to +70°C range. Short-circuit and overvoltage protection are standard. Current sharing, external synchronization, and thermal shutdown are optional. The converters are encased in 6-sided shielding. Single-output model, $175; triple-output model, $210. Delivery, six to eight weeks ARO.

Intronics, 150 Dan Rd, Canton, MA 02021. Phone (617) 828-4992. FAX 617-828-5050. Circle No. 399

CIRCLE NO 168

We've eliminated one of the biggest problems with isolating power rectifiers.

This innocent-looking item is an insulating pad.

It's commonly used to isolate a TO-220 or TO-3P power rectifier package when it's mounted on a heat sink or chassis.

Usually it works just fine.

But every once in a while, it tears during a rather tricky assembly procedure. Or it's mounted over a tiny burr that, following repeated warm-ups and cool-downs, leads to high-pot punch through.

The result can be complete system breakdown.

General Instrument has now eliminated all these problems with a family of Standard, Ultrafast and Schottky Isolated Power Rectifiers

Reliability goes up, assembly costs down, when you take away the padding.

with a current range from 5 to 40 amps. They're encapsulated in a thin epoxy layer that exhibits excellent thermal resistance characteristics.

With no further need for pads or insulating bushings and washers, the parts count is reduced. Inventory problems are minimized. And complicated manual mounting procedures are noticeably simplified.

All of which is sure to make the insulating pad a thing of the past.

For more information, contact General Instrument Corp., Power Semiconductor Division, 600 West John St., Hicksville, NY 11802. Phone (516) 933-3333.

GENERAL INSTRUMENT
Power Semiconductor Division

Power Sources

Uninterruptible Power Supply

Designed primarily for ATE (automatic test equipment) applications, Series PPS programmable power supplies feature a built-in IEEE-488 bus capability. Full-rated power outputs range from 100 to 1000W—30V at 3.5A, 40V at 7.5A, 60V at 10A, and 60V at 17A.

The supplies can operate in three modes—delta V, delta T, and manual. The units feature a remote-sensing capability and a backlighted LCD, which features adjustable contrast and illumination. All units in the PPS Series include an internal voltmeter and an ammeter that feed back information via the GPIB. An automatic programmable timer allows you to program as many as 200 voltage/current limit settings and 200 time intervals ranging from 1 sec to 10 hours. From $995.

Beckman Industrial Corp, Instrumentation Products Div, 3883 Ruffin Rd, San Diego, CA 92123. Phone (619) 495-3200. FAX 619-268-0172 **Circle No. 400**

DIP-Style DC/DC Converters
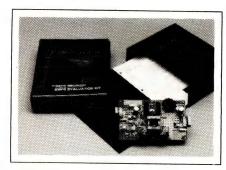
Housed in a $1 \times 2 \times 0.41$-in. case, PWR60XX dc/dc converters feature a 1.8W power capacity and offer single or dual outputs. The series includes three 5V, single-output devices that accept inputs of 5, 12, or 15V. The dual-output units generate outputs of ± 12 or ± 15V from inputs of 5, 12, or 15V. Noise and ripple for PWR60XX converters measures only 25 mV

p-p max over a 10-MHz bandwidth. Load regulation (full-load to no-load step) equals 0.5%, and line regulation measures ± 0.2%. The converters have a ± 2% accuracy rating and feature 500V dc isolation.

PWR60XX converters feature short-circuit protection, internal input and output filtering, and thermal shutdown protection as standard. The units operate from -25 to $+70$°C with no derating. $31.75 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. FAX 602-889-1510. **Circle No. 401**

DC/DC Converter Evaluation Kit

The TSC170 switch-mode power-supply evaluation kit demonstrates the techniques required for successful current-mode design. The kit consists of a fully functional 75W switch-mode power supply, CMOS PWM and MOSFET driver ICs, an instruction manual, and experiment sheets.

The switch-mode power supply serves as a learning tool for power-supply design engineers. The supply's design is a 120-kHz push/pull converter, which operates from 48 to 72V dc inputs and has 5V at 15A outputs. Sample active devices provided with the kit include the TSC170CPE PWM IC and a variety of 1.2, 1.5, and 3A dual-output MOSFET driver ICs.

The kit's evaluation board is fully assembled and tested, and includes sockets for the dual-output MOSFET driver and the PWM IC.

Presenting a battery that's not for everyone.
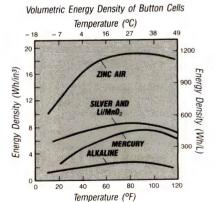
The DURACELL® Zinc Air DA1204 Cell: Only for the high energy designer.

Our new zinc air battery isn't for everyone. But if you need a small battery with high energy, it may be for you. Since the DA1204 uses the air we breathe as the cathode, it packs more energy for its size than any battery on the market. In fact, it gives you C cell size capacity (6.6 ampere hours) in less than one-third the size.*

Sealed and waiting to be used, the DA1204 has a long shelf life — maintaining 98% of capacity after one year of storage. But because it is an air-powered battery, the DA1204 has a three month life once unsealed. It performs at a constant output voltage and is perfectly suited for medium drain, continuous-use applications with average current requirements up to 150mA. And it's available in single or multi-cell configurations.

The DURACELL Zinc Air DA1204 cell isn't for everyone, but it may be the high-energy solution you're looking for. Find out more. Call or write for complete technical information on Duracell's full line of Zinc Air batteries.

Batteries shown 150% of actual size.

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Volumetric Energy Density of Button Cells

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CIRCLE NO 171

Power Sources

A current-probe loop allows you to monitor transformer current. The board also features a breadboarding area with holes and patterns on 0.1-in. centers. $129.

Teledyne Semiconductor, 1300 Terra Bella Ave, Mountain View, CA 94039. Phone (415) 968-9241. FAX 415-967-1590. **Circle No. 402**

Wide Input-Voltage-Range DC/DC Converters

Wide Range Series dc/dc converters feature a 2:1 input-voltage range—9 to 18V or 18 to 36V. The family includes 26 models that offer a variety of 5, 12, and 15V output combinations to meet the 15 or 30W requirements of most analog and TTL/CMOS circuitry.

Standard converter features include automatic voltage and current limiting on all outputs and a TTL-compatible control input for remote on/off operation. The 30W converters also provide remote-sense inputs to compensate for lead-resistance voltage drops. All units feature input-to-output isolation of 500V dc.

Efficiency figures for the converters are as high as 84%. Operating range spans -25 to $+71°C$ with no derating. From $107.

Datel Inc, 11 Cabot Blvd, Mansfield, MA 02048. Phone (508) 339-3000. FAX 508-339-6356.

Circle No. 403

75-To-200W DC/DC Converters

EMQ Series dc/dc converters offer power-output capabilities of 75 to 200W. Output voltages range from 5 to 48V, and the converters will accept inputs of 10 to 300V. If there are any instances of overvoltage or base-plate overtemperature, the converters automatically latch off. To reset the units, you simply interrupt the input voltage. Aluminum base plates, measuring 0.125 in., allow these pc-board-mountable converters to provide 50W power outputs without heat sinks or airflow.

The EMQ Series converters can be easily paralleled to operate in the $N+1$ mode for system redundancy. They also have provisions for remote sensing, voltage adjustment, and external synchronization. You can order the units with an insulated, metallized case that provides 6-sided RFI shielding. From $95 to $175. Delivery, two to eight weeks ARO.

Electronic Measurements, 405 Essex Rd, Neptune, NJ 07753. Phone (201) 922-9300.

Circle No. 404

Clean Power!

10 V/cm

VI-200™
DC-DC Converter
4.6"L x 2.4"W x 0.5"H

VI-RAM™
Ripple Attenuator Module
2.28"L x 2.4"W x 0.5"H

2 mV/cm

If Your Application Demands Low Noise Power...

...You've probably had to put up with bulky, inefficient linear power supplies to get the low ripple that wide-dynamic-range signal conditioning applications demand. In test and measurement, medical imaging, quality audio, RF, or other demanding applications, even the best switchmode power supplies haven't been able to deliver the combination of line harmonic rejection and low switching noise that your system demands. If you've ever wished for the noise performance of a linear in the space of a switcher, then...

Vicor Has The Solution...

Our high-frequency conversion architecture redefined the state-of-the-art in terms of power density and efficiency. Now we're introducing the **Ripple Attenuator Module™**, a modular companion to our family of VI-200 converters which offers the noise performance of a linear while achieving power densities up to 23 Watts/cubic inch!

Add a **Ripple Attenuator Module™** to any Vicor VI-200™ converter, MegaModule™, MasterModule™ or FlatPAC™ with output voltages from 5 to 50 Volts and limit total output noise to less than **2mV, peak-to-peak** at loads up to 10 Amps. Combining active and passive filtering, RAMs attenuate both low frequency line harmonics and high frequency switching components in the range of DC to 20 MHz...by approximately 40 dB. No adjustments are required, and remote sense and output voltage trim features are retained.

RAMs Are Available In Three Product Grades:

■ Commercial	0 °C to +85 °C	VI-RAM-C1
■ Industrial	−40 °C to +85 °C	VI-RAM-I1
■ Military	−55 °C to +100 °C	VI-RAM-M1

VI-RAMs Are Designed For Use With The Following Products:

VI-200™ Series *DC-DC Converters and Power Boosters™*

- 12 to 300 VDC nom. inputs
- Single output, 2-95 Volts
- 50, 75, 100, 150, 200 Watts
- Up to 36 Watts/cubic inch
- UL, CSA, TUV

Mega/Master Module™ Series *High Power DC-DC Converters*

- 12 to 300 VDC nom. inputs
- Single, dual and triple output
- Up to 600 Watts
- Up to 27 Watts/cubic inch
- UL, CSA, TUV

FlatPAC™ Series *High Power AC-DC Switchers*

- 115/230 VAC strappable
- Single, dual and triple output
- Up to 600 Watts
- Up to 7 Watts/cubic inch
- UL, CSA, TUV

If you'd like to try a VI-RAM, or want to know more about our complete family of component-level power products, call Vicor today at (800) 735-6200. For immediate delivery of Vicor products ask for Vicor Express at Ext. 265.

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SOFTWARE

EMERGING UNIX STANDARDS

•••••••••••••••••••••••••••••••••

may help OS's commercial growth

Thanks to increasing pressure from users (who in this sense are primarily applications-software developers), a respectable body of Unix standards is emerging. As a result, Unix is finally nearing its original design goal of being a truly portable, machine-independent operating system and programming environment, in which application programs need only be recompiled (or modified) for different computers.

Until a few years ago, there was a sharp division of opinion on the value of Unix in the "real world" of MIS and embedded systems. The academic world loved Unix—partly because AT&T distributed Unix to academic institutions at a nominal cost, but also because the availability of source code made it possible to adapt the operating system to the needs of research projects. The tools that came with Unix helped such adaptations enormously, and it was easy to create new tools. From its inception, Unix was a system-programmer's dream.

Commercial software developers, on the other hand, tended to look at Unix with a more jaundiced eye, fearing that their end users would be confused by the unfriendliness of the allegedly cryptic command set. However, the commercial developers largely ignored the Bourne and C shells, which provide a means of isolating end users from the command set's gory details. Database designers pointed grimly to the lack of record-locking facilities; in the early days this lack did indeed make Unix unsuitable for multiuser transaction-driven systems. And the Department of Defense was dubious about the security of Unix systems—there were a number of loopholes in the log-in procedures that unauthorized snoopers could make use of.

Designers of real-time embedded systems found other reasons to avoid Unix, their prime objection being the difficulty of modifying the Unix kernel to provide the strictly predictable response to external stimuli that is an absolute necessity for high-speed, real-time applications.

Under steadily increasing pressure from a new generation of application developers, who learned their business in the Unix environment and took to C like ducks to water, most of the alleged defects have been remedied. The members of /usr/group, the largest society of Unix users, proposed a number of changes and standards, many of which (including record locking) were worked into AT&T's System V. And although Unix's basic design does not lend itself to the highest levels of security, there seems to be general agreement that if care is taken in the configuration, a Unix system is now capable of obtaining a C2 security rating (level of access permissions at the discretion of the system administrator).

Vendor cooperation in developing standards, as well as the correction of some early deficiencies, are helping to give Unix credibility in the commercial marketplace.

Chris Terry, *Associate Editor*

• •
An emerging body of standards is launching Unix into the realm of a truly portable, machine-independent operating system and programming environment.

The last few years have seen a huge growth in the sales of computer hardware, especially in the areas of personal computers and engineering workstations. International Data Corp (IDC) (Framingham, MA) estimated the total sales for 1988 at $121 billion, of which IBM got the 53% lion's share (24% were machines running System/370 operating systems, 26% running DOS, and 3% running System/3). Of the remainder, Unix machines accounted for 9%, VMS machines 5%, Macintosh machines 3%, and machines with various nonstandard operating systems 30%. However, IDC projects that by 1993 the Unix share will increase to 19%, mainly at the expense of the nonstandard operating systems. Not all analysts are so sanguine—some feel that by 1993 OS/2 will be far outselling Unix, whose sales will have grown by only a modest 25% during the next five years.

It would be surprising if OS/2 did not outsell Unix—at least in the number of copies sold. OS/2 is a powerful single-user operating system for low-cost computers, and it provides multitasking facilities. It is relatively simple to install, and has sufficient power to meet the needs of most individual users. Further, PC-DOS users have a huge (and still growing) variety of software to meet all their needs, and software for OS/2 is starting to proliferate.

Unix is primarily a multiuser system; commercial versions are more expensive than PC-DOS or OS/2 and are much more complex and difficult to install. Thus, even though personal computers now have plenty of power for running Unix, and many versions of Unix can emulate PC-DOS or run PC-DOS software as a task under Unix, for the reason of cost alone, not many individual users are likely to switch to Unix. The jury is still out on the question of whether OS/2 will replace PC-DOS as the single-user operating system of choice.

In the multiuser market, however, it's a different story. In almost every multiuser installation there's a need not only for users on the same machine to share their data, but also for them to be able to run programs or use data resident on other computers of a network. Typical applications are CAE and CASE (computer-aided software engineering) systems, and small business systems that can't justify the cost of a mainframe but would be restricted in scope if they were locked into a proprietary operating system for which only a limited amount of software is available. For these, Unix is an increasingly attractive choice.

Standards are becoming vital

When you need to share data and programs across users and even across networks, the prime need is

Unix is widely used in countries whose language is not English, and several of the standard-setting bodies are working to provide standards for multilingual systems.

for standards. Unix is inherently a portable operating system, but it must behave in *exactly* the same way, regardless of whether it's running on an 80386 machine, or a 68030 machine, or a RISC (reduced-instruction-set computer) machine.

The user interface should be the same, so that if a user has to move from one workstation to another (as a CAE user may well have to do), he or she is not subjected to the confusion of a different command set or a different way of calling up a menu or help screen. The whole question of standardization for graphical user interfaces (GUIs) was discussed in a recent EDN article (**Ref 1**), but the programming and international aspects are of equal importance.

The principal strength of Unix—its portability and the availability of source code—is also (from a commercial viewpoint) one of its weaknesses. Quite early in the history of Unix, the Berkeley Systems Development department at Berkeley University created new tools and made some modifications that facilitated the system programmers' work. However, applications created for the Berkeley version could not be guaranteed to run without modification on the AT&T version, and vice versa.

Various vendors of Unix computer systems also added extensions that were undoubtedly useful, but applications that used those features often needed modification if they were to run on a Unix system from another vendor. Recognizing the need for portability of applications, some vendors have offered proprietary versions with features that reconcile these differences and can run both Berkeley Systems Development and AT&T applications. Nevertheless, the overall trend has been toward modifications that enhance the power of the hardware but impair, rather than improve, the portability of application programs.

To combat this fragmentation, a group of European computer ven-

Until a few years ago, there was a sharp division on the value of Unix in the "real world" of MIS and embedded systems.

dors founded X/Open in 1984, with the goal of developing standards that would allow compliant application software to run with identical behavior on any compliant Unix computer system. Most of the world's major computer makers have since joined X/Open. X/Open's role has been largely that of selecting technology that is already considered a de facto standard to become part of the Common Applications Environment. X/Open also runs a verification program, consisting of a suite of tests that determines whether or not a program does actually comply with the guidelines of the Common Applications Environment.

The standards situation is still complicated, however, by the fact that two other bodies are proposing standards which, particularly in connection with GUIs, are very different and not at all compatible with each other. One of these bodies, Unix International (UI), is spearheaded by AT&T and Sun Microsystems, and is proposing Open Look as the GUI of choice. The other body, Open Software Foundation (OSF), which numbers IBM, DEC, Hewlett-Packard, and Microsoft among its leaders, is proposing Motif as the GUI. Both UI and OSF have recently joined X/Open as members, and there is hope that X/Open will be able to resolve the conflict.

The move toward industry-wide cooperation is encouraging, especially because UI recently announced that AT&T's System V Release 4.0 would be compliant with the third edition of X/Open's Portability Guide (XPG3) instead of with an earlier edition of the Portability Guide. Differences are likely to persist between the two bodies but, as Art Goldberg (president and

CEO of Atherton Systems) remarked, "It's a healthy sign that we're down to two major sets of standards instead of 15 or more."

Goldberg likes the X/Open approach to standard setting because he feels very strongly that standards, to be effective, must be based upon practical implementations that are known to work well, not upon wish lists that have never been implemented. He also likes the X/Open and OSF approach of standardizing at the system-call level, because this will be general enough to allow for growth and changes in technology. Sun's proposal to standardize at the ABI (Applications Binary Interface) level is, he feels, too detailed and may prove overly restrictive.

Another set of standards that is having a unifying influence is the IEEE 1003.1 standard for a portable operating system interface (POSIX), which has been endorsed by X/Open, OSF, the National Institute for Technology and Standards, and many other organizations. DEC has been influential in helping to develop the POSIX standards, and ULTRIX (DEC's version of Unix) is fully compliant with POSIX. DEC periodically publishes the *POSIX Tracking Report* (**Ref 2**) to communicate new developments and proposals relating to POSIX.

From the UI camp comes news that Intel has concluded a deal with AT&T to produce a Unix version for 80x86-based computers. Dimitri Rotow, general manager of Intel's Integrated Microsystems Operation, says that Intel engineers worked closely with AT&T on System V Release 3.2, which was the first version for the mass market of 80386-based computers. The Unix market, he says, has thus far

been just as fragmented for 80x86-based computers as it has been for machines based on other processors. The new Intel Unix is based on AT&T's Release 4.0 and is intended to facilitate the portability of Unix application software across all Intel-based computers, provided that they conform to the Intel ABI. The new Intel Unix is designed for real-time applications, and a multiprocessor version is in development for clusters of the i860 and 80486 μPs.
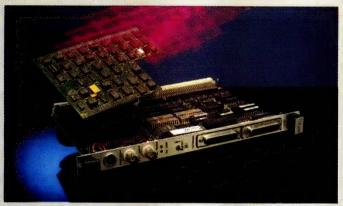
International issues

Unix is widely used in countries whose languages are not English, and several of the standard-setting bodies, including /usr/group, X/Open, and IEEE's POSIX committee, are working to provide standards and approaches for multilingual systems. The POSIX standards require that users be able to specify language-specific properties such as dates and collating sequences; they also require that users be able to conform to local cultural and legal conventions when communicating with the system. However, users can define and implement these properties and conventions as they see fit.

ANSI Standard C has provisions for specifying a "locale" that dictates how the language will match dates and sorting sequences to the local language, but not all versions of Unix support any locale mechanism even if they implement the other features of ANSI C. Also, there is still no common definition for a locale mechanism.

In particular, dates, sorting sequences, currency symbols, and the handling of accented characters that do not occur in English, require technical adjustments. The need for standards is even more

pressing when a Unix system must handle data in languages that do not use the Roman alphabet (such as Arabic and Japanese). For such languages, ANSI C provides two functions for handling ideograms. One of these (the wide-character function) requires an integer variable large enough to allow one value for every ideogram in the language; the other (the multibyte-character function) constructs an ideogram from a cluster of 1-byte characters. However, different Unix systems may use these functions in different ways.

As you can see, porting the Unix operating system or application programs to a new system is by no means the simple task that you might expect from hearing the slogan "Unix is a portable operating system." Nevertheless Unix *is* inherently portable; its early deficiencies are being remedied; it is becoming more popular for a variety of computing environments; and a serious effort to develop standards and conventions that will facilitate portability is steadily gaining momentum. **EDN**

References

1. Wright, Maury, "Graphics Environments," *EDN*, October 26, 1989, pg 152.

2. *POSIX Tracking Report*, Digital Equipment Corp (ZK03-3/Y25), 110 Spit Brook Rd, Nashua, NH 03062.

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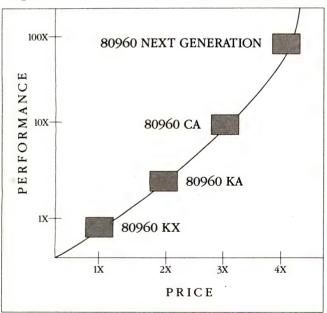
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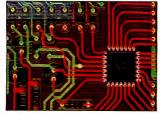
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Software

Real-time operating system and tools run on a variety of RISC and CISC μPs

A modular scalable real-time operating system called OS-9000 and a complete native and cross-development tool set support the Motorola 68020, -030, and -040 μPs, and the Intel 80386 μP. You can place all modules of the operating system in ROM; the operating system also supports disk- and LAN-based applications.

The operating system kernel can operate in either a time-sharing multiuser scheduler mode suitable for a development environment, or in a priority-based, pre-emptive real-time scheduler mode. The kernel also includes task-synchronization and process-management constructs such as pipes, events, semaphores, and signals.

Memory protection occurs through system-state-process per-

OS-9000
MODULAR SYSTEM ARCHITECTURE

missions; the operating system can take advantage of standard hardware MMUs (Memory Management Units). The operating system is written primarily in C for portability and includes a C library interface for I/O operations.

The operating system and development tools support development

on an OS-9000 native machine, cross development on Unix systems, and cross development on IBM-compatible MS-DOS-based computers. The Unix development tools are available for DEC, SUN, Hewlett-Packard, and Apollo systems. Tools include C, Fortran, and Basic compilers, and a source-level debugger.
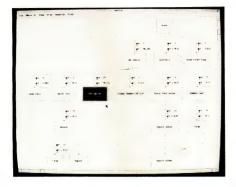
An industrial version of the product that includes the kernel, interprocess communications manager, and I/O manager costs $350. A Professional version that adds utility commands, a C compiler, documentation, and 90 days of support costs $650.

Microware Systems Corp, 1900 NW 114th St, Des Moines, IA 50322. Phone (515) 224-1929. FAX 515-224-1352. **Circle No. 689**

CASE tool tracks software execution and works backward from existing code

Whereas hardware designers have always used reverse engineering as a productive methodology, software designers weren't so lucky. Pathmap is a real-time software test tool that depicts software execution graphically and gives software designers some of the same power to work backward from existing code. The software builds upon the vendor's teamwork/SD and Software Analysis Workstation to create a comprehensive runtime view of embedded software execution.

While executing code within Pathmap, you can uncover each unique path the software uses to get to a particular module of code. You can measure the minimum, maximum, and cumulative execu-

tion time the software takes to reach important code modules, either including or excluding any child routines it spawns. Pathmap will also tell you the interval between module executions and the CPU time consumed by the module's execution. The software can

provide this data on 125 modules per measurement.

With Pathmap's analysis, your application runtime is limited by your disk size. The vendor estimates a 1M-byte trace file represents about 60,000 procedure executions. The CASE tool supports as many as 300 nesting levels.
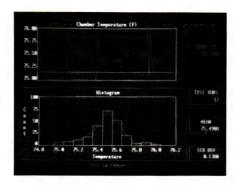
The cost of Pathmap alone is $6950, though a package of Pathmap, teamwork/SD, and Soft Analysis, a subset of the Software Analysis Workstation, starts at $24,950.

Cadre Technologies Inc, 19545 NW Von Neumann Dr, Beaverton, OR 97006. Phone (503) 690-1300. FAX 503-690-1320. **Circle No. 690**

Software

Data-acquisition software collects data from 75 different instruments

LabWindows 1.2 includes more than 20 new instrument drivers, enhanced graphing and printing capabilities, and an integrated driver for the vendor's Lab-PC plug-in data-acquisition board. The software uses Microsoft C and QuickBasic, interactive program-development tools, and a set of libraries to help you develop instrument-control, data-acquisition, and data-analysis application programs.

With the addition of more than 20 instrument-driver modules to the Instrument Library, LabWindows 1.2 can now control over 75 IEEE-488 and RS-232C, -422, and -485 instruments. The driver modules control instruments from a veritable "who's who" of instrumen-

tation manufacturers ranging from Advantest to Yokagawa and including Hewlett-Packard, Tektronix, Philips, and Schlumberger.

The upgraded Data Acquisition Library has functions for controlling the Lab-PC, a $695 plug-in data-acquisition board for IBM PCs and compatibles. The board has multi-

function analog, digital, and timing I/O capabilities. With the Lab-PC and the Data Acquisition Library, you can develop an integrated PC-based data-acquisition system that mixes a variety of instrumentation equipment.
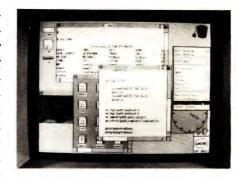
LabWindows 1.2 runs on any IBM PC or compatible with 640k bytes of memory, a hard disk, and either a 3½- or 5¼-in. floppy-disk drive. Current LabWindow users can upgrade for $195; new users must pay $495. An optional Advanced Analysis Library is available for an additional $895.

National Instruments, 12109 Technology Blvd, Austin, TX 78727. Phone (800) 433-3488. FAX 512-250-9319. Circle No. 691

OS-9-based window manager runs concurrent multiple tasks

G-Windows window manager allows you to view and access multiple tasks at the same time under the multitasking OS-9 operating system. The window manager currently operates on the G-64 bus-compatible GESVIG-4 board, which has a resolution of 640×480 pixels and can select 256 colors from a palette of 256,000. You can also adapt G-Windows to run on any commercial OS-9 systems or other industry-standard buses such as VME or Multibus.

The window manager supports full multitasking in that it simultaneously updates all visible windows. The software takes up less than 100k bytes of code and is fully ROMable so you can use it in
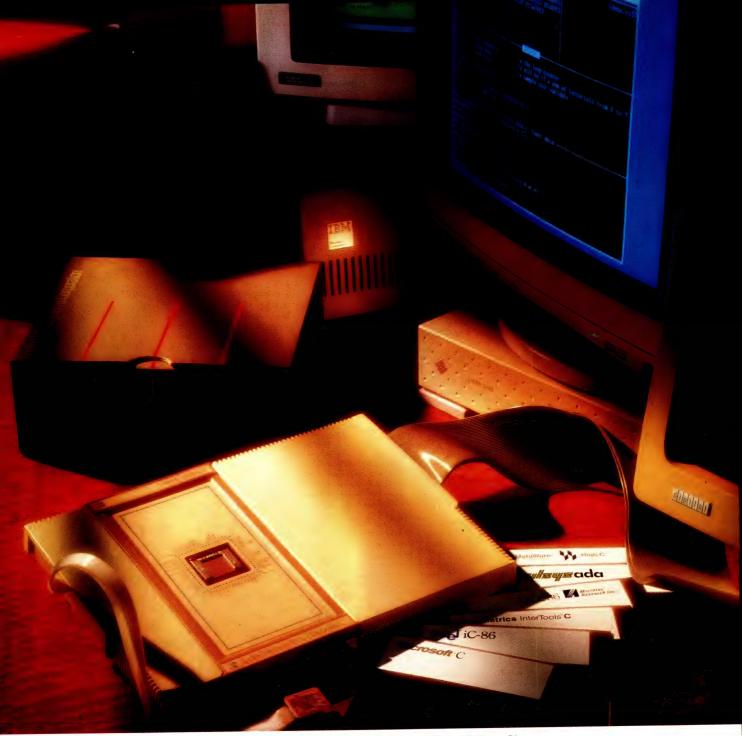
diskless embedded systems.

Each G-Windows process treats its window as if it were an entire text and graphics terminal. A process can open multiple windows and access several virtual graphics terminals concurrently. You can create windows of various sizes and windows that overlap. In addition, you

can convert windows to icons to reduce screen clutter. With a mouse, you can move windows and icons around on your display. G-Windows lets all processes attached to windows output text or graphics simultaneously.

The G-Windows developer's kit includes the C- and Assembly-language libraries that let you write applications using windows and menus. The cost of the window-manager software and developer's package is $395 for a single-user copy; the price drops for multiple licenses.

Gespac Inc, 50 W Hoover Ave, Mesa, AZ 85210. Phone (602) 962-5559. FAX 602-962-5750.

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Software

LAN Software

FlexNet release 1.44 is a protocol-independent, open-interface network extension for FlexOS, a real-time, multitasking, protected-mode operating system for IBM-compatible PCs. The software provides application-transparent and peer-to-peer connectivity between FlexOS- and DOS-based nodes and peer-to-peer connectivity for Unix-based nodes. The open interface lets you use FlexNet with any protocol and thus allows loadable drivers to handle different connectivity protocols. The drivers support the IBM NetBIOS and Server Message Block protocols as well as the TCP/IP (transmission control protocol/internet protocol) that frequently network a Unix operating system.
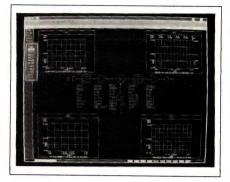
FlexNet release 1.44 is available in development and distribution packages and in the System Builder Kit, which includes Token Ring, Arcnet, and ENP-66 drivers; loadable FlexNet system software; network utilities; and an electronic mail application. $995.

Digital Research Inc, Box DRI, Monterey, CA 93942. Phone (408) 649-3896. FAX 408-649-0750.

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Microwave Simulator

The OmniSys 1.1 microwave and high-frequency analog simulator combines the linear and nonlinear
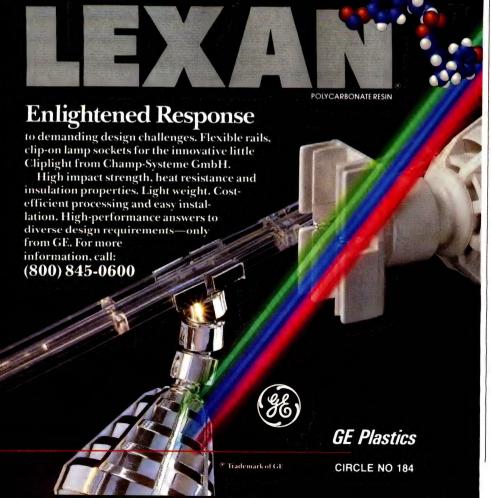
characteristics of many interconnected components to form accurate models of systems and subsystems. You can use built-in models, vendor data, measured data, or data from simulation programs to represent the characteristics of basic components. The software allows the analysis of complex time-domain signals, including AM and wideband FM modulated signals, baseband video, and RF pulses. You can also measure power levels, gain, S/N ratio, and stage-power compression at any point in your system. Additionally, OmniSys 1.1 computes production yields based on statistical behavior of individual components.

The analog simulator runs on a variety of popular workstations such as the Apollo DN3000, 4000, and 10000; the HP series 300; Sun3, Sun4, and SparcStation; the DEC VMS-based machines; and OS/2-based IBM PCs and compatibles. $14,000 to $16,800, depending on hardware.

EEsof Inc, 5795 Lindero Canyon Rd, Westlake Village, CA 91362. Phone (818) 991-7530. FAX 818-991-7109. **Circle No. 406**

G-Code Translator

G-Codes-to-DMC, a PC-based software package for motion-control systems, translates standard G-Code text files into commands for the vendor's DMC-600 servo motion controller. The G-Codes-to-DMC translator works on several modes of motion such as linear positioning of one, two, or three axes and circular interpolation of two axes. You

Software

can specify as many as 255 linear and arc segments along a continuous path for smooth contouring. In addition, by specifying M-code addresses, you can synchronize motion with other process variables such as time, position, or external inputs and outputs. The translator also supports F, I, J, L, O, R, X, Y, and Z addresses.   G-Codes-to-DMC is menu driven. You can send translated commands to the servo motion controller via a runtime executive or through a downloaded command file. The software runs on a DOS 2.0-or-better IBM PC or compatible with 512k bytes of memory. Software, $495; controller, $1495 to $1995.

Galil Motion Control Inc, 1054 Elwell Ct, Palo Alto, CA 94303. Phone (415) 964-6494. FAX 415-964-0426.   **Circle No. 407**

88k Operating System

The MTOS-UX/88k is a real-time multiprocessing, multitasking operating system for the Motorola 88000 processor. The real-time executive is presently available for the Motorola Platform 88 and should be available shortly for the Data General AViiON. The MTOS-UX/88k provides integration with Unix for access to debugging and development tools. At the programmer interface, the operating system is compatible with other versions of MTOS-UX; except for timing, an application runs the same across different versions of the OS.

MTOS-UX features a fully dynamic set of system objects; multiprocessor support with load balancing; priority-based scheduling; autoconfigurability; and complete task management. This dynamic system provides resource management, complete intertask coordination, communication and synchronization supported by signals, controlled shared variables, memory pools, message buffers, event flags, and message exchanges. The kernel

supports multitasking with prioritized task levels.

MTOS-UX allows you to use as many as 16 tightly coupled CPUs on the system bus. The executive package includes an extensive command set containing test facilities, debugging tools, validation programs, and configuration files. From $5000.

Industrial Programming Inc, 100 Jericho Quadrangle, Jericho, NY 11753. Phone (516) 938-6600. FAX 516-938-6609.   **Circle No. 408**

Unit Converter

SI Plus runs on IBM PCs, PS/2s, and compatibles, and lets you convert engineering units from one system to another (such as meters to feet, pascals to psi, curies to rutherfords, and so on). The program contains all of the unit-conversion factors commonly needed by

engineers and scientists in the course of design, development, and other operations. Because each technical discipline has its own set of commonly used units, the program contains conversion factors for all disciplines, but you can tailor the conversion tables to your own particular needs by deleting units that are of no value to you or by adding unusual units and conversion factors. You can use the program as a stand-alone utility; in addition, you can call it up from any application program by pressing Alt-F10 keys, perform the conversions you need, and return to your application at the point where you left off. The program perform more than 70,000 different conversions between units of 80 classes. $79.

Geocomp Corp, 66 Commonwealth Ave, Concord, MA 01742. Phone (508) 369-8304. FAX 508-369-4392.   **Circle No. 409**

Software

Software For Monitoring Computer Systems
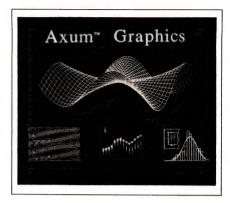
The HP Glance software package monitors the performance of HP 3000 computer systems. The program divides a terminal screen into two sections, displaying global data in one section and process-related data in the other. The global data helps you identify system bottlenecks; in the other window, you can then zoom in on the processes causing the bottlenecks and identify the specific tasks and program details that are causing the trouble. You don't need any additional hardware; the program runs on a standard HP terminal connected to the HP 3000 computer being monitored. From $600.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone local office. Circle No. 410

Graphics Software

Operating under DOS 2.1 or higher on IBM PCs or compatibles, Axum version 1.0 is a scientific graphics and data analysis program that produces full-color graphs with resolution to 4096×3120 pixels. You can customize the graphs and charts with error bars, legends, comments, symbols, lines, and arrows. Axum allows you to put multiple graphs on a page, use inserts, and rotate, shrink, or expand your displays. The software provides 21 fonts and lets you use your graphs in a number of applications such as WordPerfect, Word, Ventura, and PageMaker. You can export files to GEM, Lotus PIC, HPGL (Hewlett-Packard Graphics Language), Tektronix, and Encapsulated PostScript files, and you can import such files as ASCII, Lotus, and dBase.

Axum stores data in 4-byte single precision and performs computations in double and extended precision (8 bytes and 10 bytes, respectively). Smoothing functions such as polynomial regression, 2-D and 3-D

Axum™ Graphics

splines, and weighted average smoothing are among the tool's forte. Statistical analysis includes computation of means, standard deviations, sums, variance, correlations, frequencies, and regressions. Axum requires a hard disk with at least 1.5M-bytes of available memory, 640k-bytes of main memory, and a computer graphics card. $495.
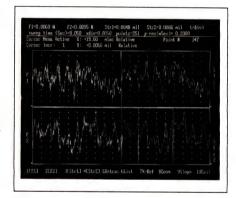
TriMetrix Inc, 444 NE Ravenna Blvd, Suite 210, Seattle, WA 98115. Phone (800) 548-5653. FAX 206-547-0328. Circle No. 411

C++ Software-Development Tool Set

Objectworks for C++ is a set of software-development tools that lets you create and manage object-oriented system and application programs written in C++. Objectworks for C++ runs on Sun-3 workstations under SunOS 3.2 or higher. The package includes AT&T's C++ Language System, release 2.0. You create your programs using a mouse-oriented editor, which provides syntax-error-message annotation and an on-line query and help facility. Alternatively, you can use any full-screen editor such as *vi* or EMACS. The incremental compiler/linker module first calls up the C++ translator, which generates standard C code, and then calls the host's standard C compiler. Finally, it links the new or modified functions. For debugging, you use the interactive, source-level, symbolic debugger.

The source-code browser lets you view the class hierarchy and file structure of application code; you can search for implementors or callers of a function, or references to data types. The category browser provides an abstract level of program organization. The change-management tools help you keep track of source-code updates and provide change-rollback and infinite undo facilities. To run Objectworks for C++, your Sun-3 must have at least 8M bytes of RAM and 20M bytes of free disk space. $2495.

ParcPlace Systems, 1550 Plymouth St, Mountain View, CA 94043. Phone (415) 691-6700. FAX 415-691-6715. Circle No. 412

Data-Acquiring Software

Snapshot Storage Scope, working with an analog I/O board, can capture 80 analog channels of data at a sampling rate of 1 MHz. The software displays as many as eight channels, defines units and labels for each channel, averages trigger-synchronized waveforms, generates X-Y plots, and reads and provides the option to write data files. The code supports both pre- and postevent triggering using either digital or analog signals. Trigger criteria include threshold and slope values.

Some additional capabilities of the software are real-time acquisition with 12-, 14-, or 16-bit accuracy; a selectable sampling rate ranging from less than two samples/hour to as many as a million sam-

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ples/sec; selection of individual channel gains; and support of an external clock to sequence the A/D converter. The tools run on IBM PCs or compatibles and work with boards from Acrosystems, Analog Devices, Burr-Brown, Contec, Data Translation, and MetraByte. The Automatic Parameter Entry Checking System feature in the software's user interface checks all data entries to ensure validity. $495.

HEM Data Corporation, 17336 12 Mile Rd, Suite 200, Southfield, MI 48076. Phone (313) 559-5607. FAX 313-559-8008. Circle No. 413

Multitasking Tutor

A reduced version of *smx* (simple multitasking task), *smx* CK (college kit), includes all the important calls and features of the full version. The subset operates at full speed and

is ROMable. The package includes a "protosystem" to which you can add your own code, *make* files, a tips file containing helpful hints and guidelines, a program that lets you time *smx* operations, and other useful utilities. The User's Guide is tutorial in nature and encourages you to develop a multitasking application as you read, using the protosystem as the foundation. The package also includes a complete reference manual. *smx* CK runs on systems based on µPs of the Intel 80X86 family and works with Micro-

soft's and Borland's C compilers and assemblers. $95.

Micro Digital Inc, 6402 Tulagi St, Cypress, CA 90630. Phone (714) 891-2363. Circle No. 414

Z8 Symbolic Debugger

The Micro/SLD-Z8 symbolic debugger executes Z8 machine code on an IBM PC or compatible development host. The built-in simulator means that you don't need any additional hardware, such as the target system or an in-circuit emulator, to debug your programs. You can step through programs written in C or assembly-language (or a combination of both) line by line, or run at full speed until the debugger encounters a breakpoint in the code or data. Separate windows display the source code as well as the contents of Z8 hardware registers and data variables stored in memory.

The debugger works with the vendor's Micro/C cross-compiler and assembler package, or with any assembler that can generate output in Intel Hex format. The debugger supports 19 versions of the Z8, including CMOS parts, and handles all on-chip devices such as the UART, timers, and interrupt controller. $295.

Micro Computer Control Corp, Box 275, Hopewell, NJ 08525. Phone (609) 466-1751. FAX 609-466-4116. **Circle No. 415**

DOS Extenders

OS/286 and OS/386 DOS extenders facilitate the development of application programs that can address as many as 16M bytes of memory in protected mode on an 80286, or as many as 4G bytes on an 80386. You can also run 80386-based applications in multitasking systems.

Both extenders now adhere to the virtual control program interface specifications that allow them to run under DESQview 386 to provide multitasking capabilities. The kernel now occupies only 40k bytes of the 640k-byte address space, so it can run in real mode with other large resident programs. OS/386 has a Virtual-8086 mode that allows real-mode applications to address as much as 900k bytes of memory. Real procedure calls allow selected portions of an application to run in real mode while the remainder of the application runs in protected mode. Both OS/286 and OS/386 come with two utilities: Tune and .EXPress. Tune is a setup program that automatically configures the extender for optimum performance on your specific system. The EXPress utility permits direct, 1-step conversion of a real-mode executable file to protected-mode, thereby

simplifying debugging and removling the 640k-byte limit of real mode. Developer's Kit, which includes the full suite of development tools, $495.

A I Architects Inc, 1 Intercontinental Way, Peabody, MA 01960. Phone (508) 535-7510. FAX 508-535-7512. **Circle No. 416**

PC Diagnostic Tool

The QAPlus is a menu-driven diagnostic tool for IBM PCs, PS/2s, and compatibles. One version runs on all systems and automatically identifies the processor and bus type, as well as the presence or absence of a math coprocessor. The hardware-configuration checks report the amount of base, extended, and expanded memory; the video mode you're running; and the capacity of all floppy and hard disks. The CPU test checks the processor, DMA/Mi-

Software

cro Channel Architecture (MCA) channels, interrupt controllers, clock/calendar operation, and the protected mode of operation on 80286- and 80386-based systems. The memory test provides a wide variety of write patterns to ensure that all memory errors are found, including parity errors and bent pins; the report explicitly identifies each bad chip. Other tests include a keyboard test (including mouse and joystick tests), a video test, and a low-level hard-disk formatter that allows you to select the interleave interval and to edit bad-track tables. Benchmarks report CPU performance (in Dhrystones), math performance (in Whetstones), system speed (in megahertz), and video performance. The program reports all errors in English (not numeric codes) and suggests the most likely causes of each error. $134.95.

DiagSoft Inc, 6001 Butler Lane, Scotts Valley, CA 95066. Phone (408) 438-8247. FAX 408-438-7113. Circle No. 417
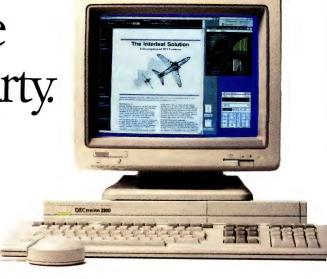
Postscript On Fax

GammaScript converts images that you've produced with application programs that support PostScript into a form that you can send directly to a fax machine. Because you don't need to scan hard copy of the image, the received fax looks exactly as if it were printed on a 200-dpi PostScript printer. In addition to converting PostScript files, the program can also convert HP-GL and AutoCAD plotter-language files for fax transmission. To run the program you need an IBM PC/AT, PS/2 Model 50, or compatible, that has at least 1M byte of RAM, 4M bytes of free disk space, and a GammaFax PC-to-fax board. Two

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versions are available: GammaScript Starter gives you 13 fonts compatible with the original Apple LaserWriter; GammaScript gives you 35 fonts compatible with the Apple LaserWriter NT. If you order the Starter version, you can later obtain the other 22 fonts in

an upgrade package. GammaScript Starter, $145; GammaScript, $440; upgrade package, $295.

GammaLink, 2452 Embarcadero Way, Palo Alto, CA 94303. Phone (415) 856-7421. FAX 415-494-7042. Circle No. 418

Language Translator

Metamorphosis is a generic computer program that runs on IBM PCs and compatibles that have at least 416k bytes of RAM and two disk drives. When given files containing the syntactical definitions of a source language and a target language, the program can translate programs written in the source language to functionally identical programs written in the target language. You can use the generic version to implement compilers, assemblers, macroprocessors, and query-language processors; to reformat character-oriented database files; to analyze grammar and to analyze and convert sequential to parallel procedures; and to perform many other conversion tasks. In addition to the generic version ($387), you can obtain three prepackaged translators to convert from Fortran IV to C ($87), from PL/I (Subset G) to C ($87), and from CMS-2M to Ada ($134).

Shannon Associates Inc, Box 597, Chapel Hill, NC 27514. Phone (919) 929-6863. Circle No. 419

C++ Compiler

The HCR/C++ compiler is 100% compatible with AT&T's Release 2.0 of C++, and comes bundled with dbXtra, an enhanced window-based implementation of the widely used dbx debugger. HCR/C++ provides all the features of AT&T's Release 2.0, such as multiple inheritance, type-safe linkages, and default-membership initialization. Because the compiler translates all C++ code into C before execution, you can use the dbXtra debugger to examine either the original C++ code or the derived C code during debugging. The documentation includes Stroustrup's book *The C++ Language*, together with extensive descriptions of how Release 2.0 differs from the definitions in the book, and full installation and operating instructions. Introductory price, $499.

HCR Corp, 130 Bloor St W, 10th floor, Toronto, Ontario, Canada M5S 1N5. Phone (416) 922-1937. FAX 416-922-8397. Circle No. 420

CASE-Tool For Embedded-Control Systems

AutoCode/Matrix$_x$ 2.0 provides all of the functions needed to design

and implement the software for an embedded-control system. The package unifies a graphic modeling system with engineering analysis, plotting, simulation, real-time code generation, and automatic documentation facilities. The graphic modeling system lets you design and specify the target system; the simulator lets you simulate the operation of the controller and attached peripheral devices. The analytical features let you perform frequency and stability analysis; linear algebra and equation solving; design optimization; and plotting for data visualization. The code-generation module automatically generates full software code from your completed design. The documentation module automatically generates detailed design documentation that conforms to MIL-STD-2167A requirements and creates hypertext links to requirement and testability information. The package runs on VAX, Sun, or Apollo workstations. $25,000 to $40,000 for a single workstation, depending on the features you want.

Integrated Systems Inc, 2500 Mission Blvd, Santa Clara, CA 95054. Phone (408) 980-1500. FAX 408-980-0400. **Circle No. 421**

Security Shell

The Integrity Shell is a self-testing command interpreter (shell) for PC-DOS and MS-DOS computers. The shell works with the standard COMMAND.COM and uses a pseudocryptographic checksum to test each program as DOS loads it. If the checksum computed during loading differs from the checksum that the shell originally embedded in the known-good version, the shell inhibits execution and notifies you that the program has been modified (possibly by a virus). Because Integrity Shell works with, and provides all the facilities of, COMMAND.COM, the shell is totally transparent and cannot cause conflicts with programs of the TSR (terminate-and-stay-resident) type. Another advantage is that the pseudocryptographic checksum is very difficult for a virus to break, and is therefore more secure than the CRC (cyclic redundancy checksum) used by most antiviral programs. $59.95.

MDC Software Inc, Box 10589, State College, PA 16805. Phone (814) 238-7321. **Circle No. 422**

Translator

The M2CC/C translator package consists of three programs and a standard library in the form of definition and object modules. The first program, M2CC, is a single-pass

compiler that accepts Modula-2 source code and translates it into processor-independent intermediate code. You can optionally request a list file with integrated error messages. The Modula-2 language definition of M2CC is based on the third, revised edition of Niklaus Wirth's book *Programming in Modula-2* (Springer Verlag, Berlin and New York, NY). The second program, M2C, processes the intermediate code and generates a C source file that you can compile to object code using any ANSI-C compiler. M2C processes the intermediate code procedure by procedure and module by module; the output is well structured, and you can integrate standard C libraries into the translated program. The third program, Mak, analyzes a Modula-2 program that consists of multiple compilation units and generates from the program a *make* descrip-

tion file. You can use this description file with the Unix *make* utility to automatically create a consistent program version. PC-DOS version, SFr 1500; VAX/VMS version, SFr 5000.

Glance Ltd, Gewerbestrasse 4, CH-8162 Steinmaur, Switzerland. Phone 01/853-39-49. FAX 01/853-08-09. Circle No. 423

Metacompiler

The LMI Forth metacompiler is a cross-compiler that runs on IBM PCs, PS/2s, and compatibles. The compiler generates native code for the Harris RTX-2000 μC, whose instruction set maps so closely onto essential Forth-language elements that there is no need for an assembler. The metacompiler is a multipass, table-driven translator that allows local labels and conditional compilation directives. It lets you

define and invoke new defining words and immediate words in the target code; optionally generates "headerless" code to conserve memory in the target system; and can generate both ROM-resident and RAM-resident code. The metacompiler can even create a new interactive Forth interpreter/compiler that will run on the target system. To run the metacompiler, you'll need a PC, PS/2, or compatible that has at least 320k bytes of RAM and 400k bytes of free hard-disk space, and runs PC-DOS 2.0 or later. You can order it either on two 5¼-in. disks or one 3½-in. microdisk. Other versions of the metacompiler are available for a variety of 8-, 16-, and 32-bit processors from Intel, Motorola, and TI. $750.

Laboratory Microsystems Inc, Box 10430, Marina del Rey, CA 90925. Phone (213) 306-7412. FAX 213-301-0761. Circle No. 424

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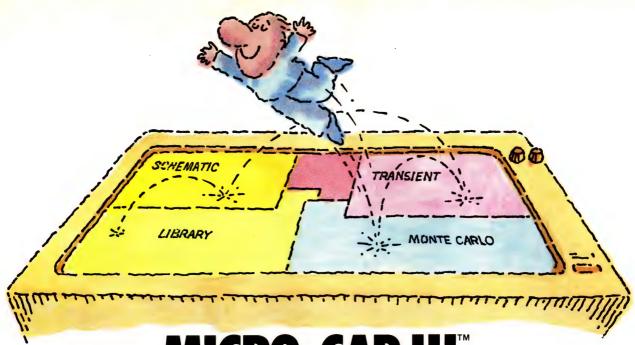
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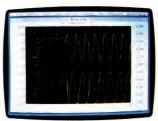
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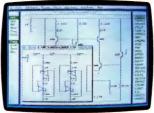
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CIRCLE NO 187

DESIGN IDEAS

EDITED BY CHARLES H SMALL

Circuit drives motor in quarter steps

Carl Spearow
Sundstrand Corp, Rockford, IL

Although it doesn't offer the performance of a micro-stepper, the low-cost, 2-IC circuit in **Fig 1** provides twice the resolution of a half-step stepper-motor driver.

The host controller must sequentially apply an ascending 4-bit count to the PROM. **Table 1** lists the PROM's contents. The PROM, in turn, drives the Sprague ULN-2805A octal high-current driver, which energizes the motor's windings. Two drivers are connected to each winding; one directly, and one through a 75Ω resistor. Thus the circuit can supply two levels of current to each winding: a high level and a low level.

To get the proper relationship between the high and low current levels, you must select the series resistor to be $\sqrt{2}$ times the motor's winding resistance. Set the low current level to tan(22.5°), or 0.414, times the high current level.

For example, for an Airpax L82401, which has 52.4Ω windings, the circuit requires 75Ω resistors. The driver IC can sink as much as 350 mA. Although higher-current drivers are available, this technique best suits low-power applications. For large motors, power dissipation becomes excessive, and a switching technique would be more practical. You could eliminate the PROM if your host controller can supply the sequenced 8-bit codes directly to the driver. Or you could store alternate sequences in the upper 16 bytes of the PROM for other sequences, such as a reverse-direction sequence.

Table 1 — PROM contents and normalized winding currents

address	D7	D6	D5	D4	D3	D2	D1	D0	hex	I_1(A)	I_2(A)	I_3(A)	I_4(A)
0	0	0	0	0	0	0	1	1	03	1	—	—	—
1	0	0	0	0	0	1	1	1	07	1	0.41	—	—
2	0	0	0	0	1	1	1	1	0F	1	1	—	—
3	0	0	0	0	1	1	0	1	0D	0.41	1	—	—
4	0	0	0	0	1	1	0	0	0C	—	1	—	—
5	0	0	0	1	1	1	0	0	1C	—	1	0.41	—
6	0	0	1	1	1	1	0	0	3C	—	1	1	—
7	0	0	1	1	0	1	0	0	34	—	0.41	1	—
8	0	0	1	1	0	0	0	0	30	—	—	1	—
9	0	1	1	1	0	0	0	0	70	—	—	1	0.41
A	1	1	1	1	0	0	0	0	F0	—	—	1	1
B	1	1	0	1	0	0	0	0	D0	—	—	0.41	1
C	1	1	0	0	0	0	0	0	C0	—	—	—	1
D	1	1	0	0	0	0	0	1	C1	0.41	—	—	1
E	1	1	0	0	0	0	1	1	C3	1	—	—	1
F	0	1	0	0	0	0	1	1	43	1	—	—	0.41

NOTE: Addresses 10 to 1F hex unused.

To Vote For This Design, Circle No. 746

Fig 1—This quarter-step stepper-motor driver provides two levels of current to each winding.

DESIGN IDEAS

Bidirectional switch replaces relays

Benno Dreier
Standard Elektrik Lorenz AG
Stuttgart, Germany

Although the solid-state switch and its associated driver in **Fig 1** were designed to replace electromechanical relays in telephone systems, you can use the circuit anywhere you need a bounce-free, bidirectional, low-RFI, isolated switch.

The circuit's passive components form a capacitively coupled switch driver for the n-channel MOSFETs, Q_1 and Q_2. Conceptually, the driver consists of two voltage doublers (**Fig 2**) that share D_2, R_1, and the MOSFETs' gate-source capacitances. As the CLK and $\overline{\text{CLK}}$ signals change state, they drive their respective doublers, thus causing charge to flow into C_1 and C_2, and ultimately into the MOSFETs' gate capacitances. When the clock signals cease changing state, R_1 drains the gates' charge, thus turning off the MOSFETs.

The MOSFETs' turn-on delay from the time the CLK signals begin oscillating is considerably longer than the rise time of the clock signals. The formula for determining the delay is

$$t_{ON} = \frac{12\,C_{GS}}{C_{1\,OR\,2}} \times \frac{1}{f_{CLK}} \times \frac{V_{TH}}{V_{CLK} - 3\,V_{DF}},$$

where V_{CLK} is the on voltage of the drive signals, V_{TH} is the threshold voltage of the MOSFETs, and V_{DF} is D_1 or D_3's forward voltage. The switch's turn-off time is

$$t_{OFF} = 2\,C_{GS} \times R_1,$$

where C_{GS} is the MOSFETs' gate-source capacitance.

To minimize switching-induced RFI, use a fast inverter to develop the CLK and $\overline{\text{CLK}}$ signals. The rise and fall times of the CLK signals should be about six times the skew between the CLK and $\overline{\text{CLK}}$ signals. The skew arises, of course, from the gate delay, t_{PD}, of the inverter; R_2 and R_3 in **Fig 1** slow the rise time of the inverters' outputs to meet this requirement.

The driver circuit works from a single 5V supply and delivers a minimum of 4.5V dc at its output terminals if you follow these design rules:

$$\frac{C_{GS}}{10} > C_{1\,OR\,2} > 5 \times C_{DIODE}.$$

EDN

To Vote For This Design, Circle No. 747
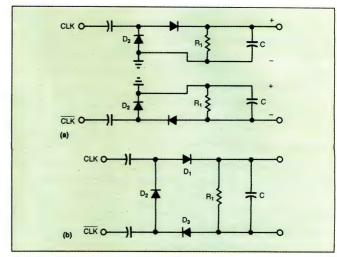
Fig 2—The bidirectional switch circuit essentially combines two voltage doublers (a) into one circuit (b).

NOTES: D_1, D_2, D_3 =1N4148
C_1, C_2 =20 pF±10%
R_1 =1M, R_2, R_3 =1k
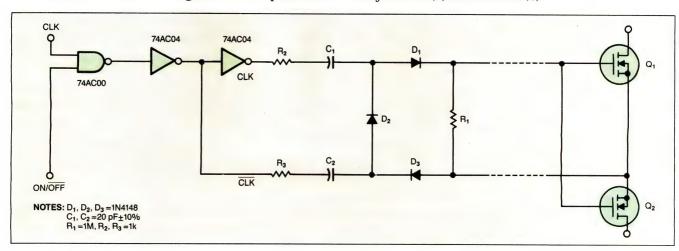
Fig 1—This bidirectional isolated switch uses voltage doublers to turn on the switch's MOSFETs.

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National Remote Sensing Agency
Hyderabad, India

The circuit in **Fig 1** converts input-clock pulses to the switching sequence needed to drive a 4-phase stepper motor through 400 half steps of 0.9°, each half step at one-eighth of the input clock's frequency. The CCW line determines the motor's direction of rotation. When CCW is high, the motor rotates counterclockwise; when CCW is low, it rotates clockwise. The resistor and capacitor set the driver's output to a predetermined state upon power up.

EDN

To Vote For This Design, Circle No. 748
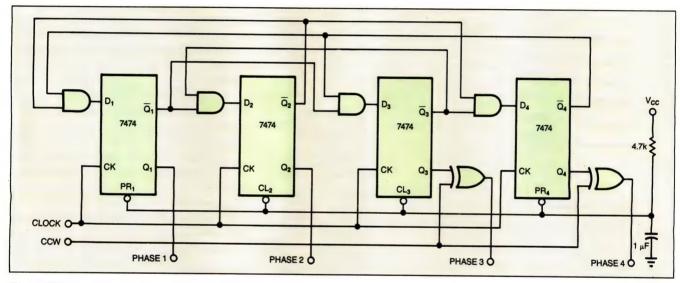
Fig 1—This circuit can drive a stepper motor in half steps.

Detector spots double sheets

Sheng-Feng Hwang
Norfin International, Seattle, WA

The circuit in **Fig 1** can detect when a paper feeder spews two sheets of paper when it should feed only one sheet at a time. This self-calibrating circuit employs a capacitor formed from two metal sheets measuring 2×15 in. and separated by a 0.1-in. air gap. Elementary calculations yield a capacitance of 67.44 pF for this air-gap capacitor. With one sheet of 20-lb paper in the gap, the capacitance increases because the paper increases the capacitor's dielectric constant by about 0.8%. This rate of increase is fairly linear; for example, 1.6% for two sheets of paper.

The inverters, IC_{1A}, IC_{1B}, and IC_{1C}, and the metal-plate capacitor, C_1, constitute an oscillator that runs at varying frequencies depending on the amount of paper between the capacitor's plates. The output of the oscillator goes to a frequency-to-voltage converter. An op amp, IC_{3A}, inverts the converter's output.

The inverted dc output signal from the frequency-to-voltage converter appears on either output pin 10 or output pin 9 of the analog switch, IC_4, depending on whether the reflective sensor detects any paper between the plates of C_1 or not. The reflective sensor detects the presence of paper—but not the number of

sheets—between the plates of C_1. IC_{3B} is a voltage comparator that trips upon detecting the double-sheet condition.

When there is no paper in C_1, C_6, via switch C of IC_4, stores a reference voltage proportional to the oscillator's frequency. The circuit updates this voltage continuously so that the circuit can adjust automatically for environmental changes.

When a sheet of paper passes through C_1, the reflective paper sensor switches the voltage-to-frequency converter's dc output signal, which is proportional to the oscillator's new frequency, to pin 10 of IC_{3B}. The comparator will change state if two sheets of paper are between C_1's plates if you adjust VR_2 properly.

You should set VR_2 so that the comparator trips when the voltage at pin 10 is greater than half of the percentage change of capacitance between one sheet and two sheets of paper. For 20-lb paper, the halfway point is 1.2%. Using voltage-divider relationships,

$$1/R_{11} = (1 + 0.012)/(R_{11} + VR_2).$$

Therefore,

$$VR_2 = (90.1k \times 1.012) - 90.1k = 1.08k.$$

Using a 5-kΩ potentiometer for VR_2, the circuit would have enough of an adjustment range to detect double feeds of 20- to 110-lb paper. **EDN**

To Vote For This Design, Circle No. 749
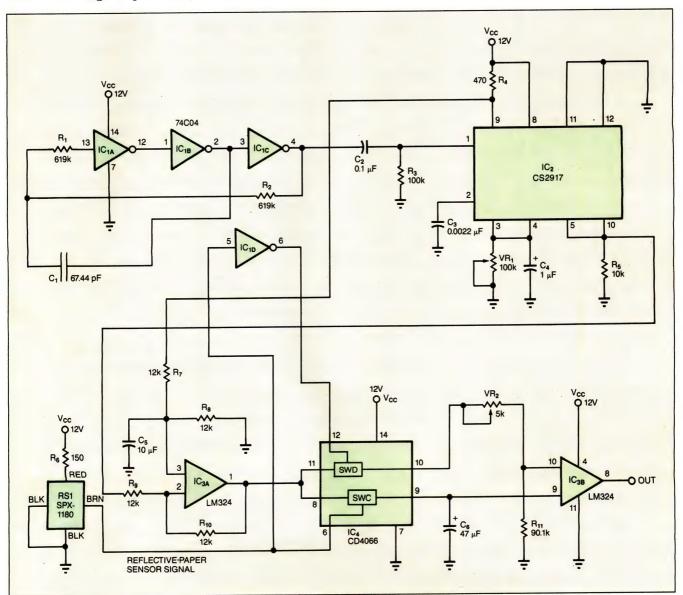
***Fig 1—This circuit's comparator** changes state whenever its capacitive sensor detects two or more sheets of paper.*

3-wire receiver demuxes messages

Harry H Marsh
Tektronix, Beaverton, OR

The 3-wire receiver in **Fig 1** checks the first four of 16 received bits against a preset 4-bit address. If the two match, it latches the remaining 12 bits into a pair of hex flip-flop registers, IC_4 and IC_5.

Because a gated clock drives the receiver, the receiver doesn't need a separate sync line to tell it when an address-data packet begins. The dual one-shot, IC_6, generates the data-valid enabling pulse for the comparator after the gated clock stops. You should set the period of the first one-shot at about 1.5 times the gated clock's period for retriggerable one-shots and at 1.1 times that value for nonretriggerable one-shots.

You can use 3-lead shielded cable and differential line drivers to fashion a multidrop network of these receivers. And you can use any logic family, CMOS or TTL, in the receiver's design. **EDN**

To Vote For This Design, Circle No. 750
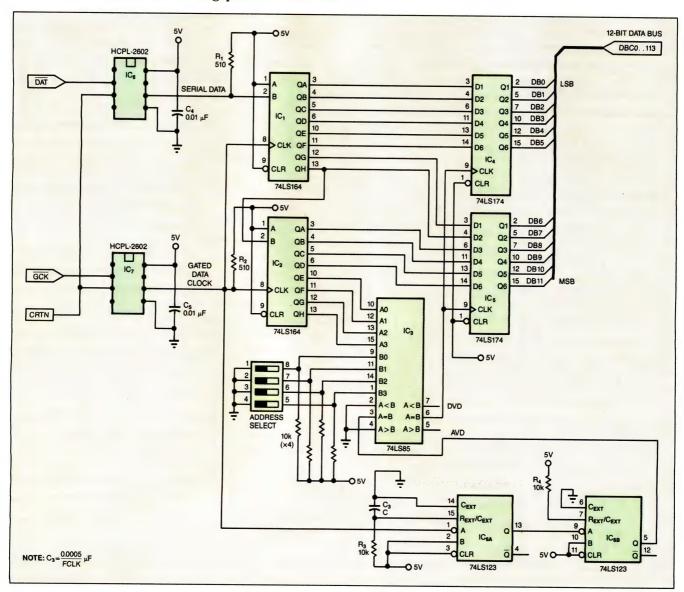
Fig 1—This multidrop receiver senses the cessation of the gated clock to determine the end of a 16-bit address-data packet. It then compares the first four bits against a preset address and latches the remaining 12 bits if the addresses match.

NOTE: $C_3 = \dfrac{0.0005}{F_{CLK}}\ \mu F$

DESIGN IDEAS

FEEDBACK AND AMPLIFICATION
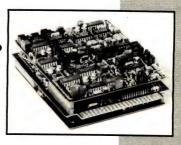
Misunderstanding leads to new policy

We apologize for any misunderstanding caused by the term "nominal fee" in Thom Van Nguyen's Design Idea "Program generates pseudonoise" (EDN, September 28, 1989, pg 166). Our definition of nominal fee is "no profit, materials and shipping fees only." We didn't intend to offer any product for sale or imply that the author was profiting from his Idea. His program was simply too long for us to publish, and the author agreed to send copies to interested readers for the cost of the disk. Please address future requests for Thom Van Nyugen's program to his home: 7804 Norcanyon Way, San Diego, CA 92126. Include a floppy disk and a self-addressed stamped envelope.

If you wish to submit a software-related Design Idea, in addition to the listing please include a brief flow diagram or algorithm (with the Idea) that we can print to give readers a general idea of the program's operation. If your Design Idea contains a listing longer than one page, we will print either your work or home address (whichever you request) so that readers can contact you directly to obtain a copy.

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For those who need large servings of 256K SRAMs, the selection until now has been somewhat limited. The new INMOS 256K SRAM range extends the menu.

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requirement, and at competitive prices. Just what you'd expect from the largest fast SRAM supplier outside Japan.* These 256K devices join our extensive range of 4K, 16K and 64K fast SRAMs, all of which are available in commercial and military (MIL-STD-883C) versions and manufactured to the highest standards by Europe's leading SRAM manufacturer. For a copy of our Memory Databook or, of course, a quote, contact your local SGS-THOMSON Microelectronics/INMOS office. ⬤ **inmos**

*Source: Dataquest

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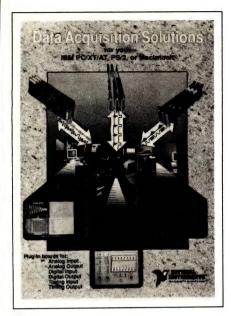
Most importantly, with the experience and expertise of Systech and Systems Strategies, Inc., you'll be in step with the latest software and hardware developments. And you'll always be OneStep ahead of the competition.

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CIRCLE NO 193

Booklet features data-acquisition products

This 6-pg foldout brochure highlights the company's broad line of data-acquisition hardware, software, and accessories for IBM PC, PC/XT, PC/AT, PS/2, and Macintosh computers. The publication provides specifications for plug-in data-acquisition boards for analog, digital, and timing I/O functions. The pamphlet features the Real Time Integration bus, which is used to route timing and trigger signals between multiple data-acquisition boards. Also covered are the LabDriver, LabWindows, Measure, and LabView software products.

National Instruments, 12109 Technology Blvd, Austin, TX 78727.　Circle No. 373

Precision measurement and control systems cataloged

This 6-pg catalog encompasses the company's line of PC-based systems. The foldout publication discusses the Acro-400 Series, a family of intelligent, data-acquisition and control systems, as well as the Acro-4000 Series, which combines any of the Acro-400 I/O systems with the Acro-420 industrial computer to provide complete data collection and process-control worksta-

tions. Also included are the high-precision Acro-900 Series of I/O systems and the AT-6400 multichannel waveform digitizer.

Acrosystems Corp, 66 Cherry Hill Dr, Beverly, MA 01915.
　　　　　　　Circle No. 374

Data sheets for single-board computers

The vendor offers two data sheets for its QPC-5136 and QPC-5142 single-board computers. The publications provide specifications and illustrations of the boards that are designed for rugged industrial environments.

Qualogy, 1751 McCarthy Blvd, Milpitas, CA 95035.
　　　　　　　Circle No. 375

Handbook for PC data-acquisition products

The PC I/O Guide Book, a "how-to" catalog for PC data acquisition, test, measurement, and control, covers plug-in carrier boards and modules. It also includes a complete software library and guidance for configuring a cost-effective data-acquisition system for IBM PCs, PC/XTs, PC/ATs, and compatible computers; PS/2 model 30; and 386-type computers. The book features the IQ Workstation, the PC Expander, and SuperBoards, as well as the company's line of digital signaling packages.

Intelligent I/O, 1141 W Grant Rd, MS 131, Tucson, AZ 85705.
　　　　　　　Circle No. 376
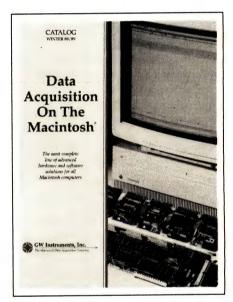
Integrated approach to robotics

A 336-pg hardcover book, entitled Industrial Robotics, Machine Vision, and Artificial Intelligence, emphasizes how the integration of machine vision and AI with a flexible automation/manufacturing system can enhance manufacturing in the future. Some of the topics cov-

ered include components of robot systems, machine vision systems, analysis of 2-D images, 3-D machine vision, sensors for robot-based assembly, AI basics, AI in manufacturing, and AI/expert systems scheduling in manufacturing. $39.95.

Howard W Sams & Co, 4300 W 62nd St, Indianapolis, IN 46268.
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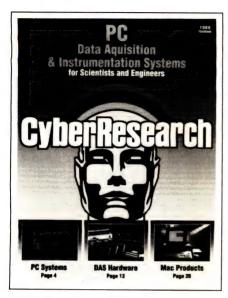
Catalog outlines products for hardware solutions

This 56-pg publication gives detailed product descriptions and technical specifications. The book features application notes for the company's MacAdios family of data-acquisition and control hardware, software drivers, and applications software, as well as the MacAdios II and MacAdios II Jr multifunction I/O boards that plug into the Macintosh II Nubus. Included in the listing of the company's line of data-acquisition and control software products are TurboDrivers, software driver routines, and comprehensive applications software products such as MacInstruments, MacAdios Manager, Labtech Notebook, and LabView.

GW Instruments Inc, 35 Medford St, Somerville, MA 02143.
　　　　　　　Circle No. 377

Handbook of PC systems

The 1989 *PC Systems Handbook for Scientists and Engineers* outlines recent, as well as standard, products for PC-based data acquisition and process control. Included in the book are ADCs, multiport serial boards, IEEE-488 interfaces, digital-oscilloscope boards, and PC expansion chassis for use with IBM-compatible computer systems. The write-up of recent products includes Micro Channel peripherals to use with IBM's PS/2 line; an entire section covers products that run with Macintosh II/IIx and Macintosh SE machines.

CyberResearch Inc, Box 9565, New Haven, CT 06536.

Circle No. 378

Guide leads to boards for IBM PCs and Mac II

The company's Volume 21 Catalog provides a complete guide to all its data-acquisition and control-interface boards for the IBM PC, PC/XT, PC/AT, PS/2, Apple Macintosh II, and compatible microcomputers. Featured in the 304-pg handbook is the WorkHorse, a family of high-speed industrial control and monitoring products. The publication also highlights the PCIP-Scope, a single-board, digital-sampling oscilloscope; the DAS-HRES 16-bit

data-acquisition board; the MV2 frame-grabber board; VOS/DVOS software; and the MBIC computers, a series of 19-in. rack-mount IBM PC-compatible industrial computers. The catalog provides selection guides and complete technical and price information.

Metrabyte Corp, 440 Myles Standish Blvd, Taunton, MA 02780.

Circle No. 379

Pamphlet describes 12-in., 90° monitors

This technical brochure presents dimensions, photographs, a standard product specifications chart, and customizing options for the vendor's 12-in., 90° monochrome display monitors. The schematics and general specifications help you select the best monitor for your application.

DisplayTek Inc, 1355 Holmes Rd, Elgin, IL 60123.

Circle No. 380

Listing of data-acquisition products

The company's Volume 2 covers its IBM PC bus data-acquisition and control products. The 22-pg catalog provides technical descriptions, programming information, and application notes for 11 IBM PC, PC/XT, and PC/AT interfaces, including ADCs, DACs, digital I/O boards, prototyping, and timer/counter boards. The publication also illustrates three technical books that deal with PC interfacing.

Real Time Devices Inc, Box 906, State College, PA 16804.

Circle No. 381

Brochure presents system-switching modules

Thirty-two switching-matrix, multiplexing, and scanner modules are described in this 25-pg brochure. This publication also provides a switching-matrix-card selector

guide with information about switch type, card configuration, maximum switching levels, contact potential, maximum recommended frequency, and common applications. Further, a selector guide for accessories lists connector kits, tools, and adapters, as well as other accessories, and details their applications.

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139.

Circle No. 382

Note explores matrix switching

The vendor's product note PN 8760-1, "HP 8760 Series Custom Switch Matrixes for Microwave ATE," discusses capabilities for configuring, producing, and testing complex switching assemblies. The publication spans matrix theory and practice from simple 1-channel matrixes to full-access models that have numerous inputs and outputs. The note instructs you in specifying performance and in methods of documenting test procedures and construction. Also included are several ideas for internal self-test configurations.

Hewlett-Packard, Company Inquiries, 19310 Pruneridge Ave, Cupertino, CA 95014. **Circle No. 383**

EDN December 7, 1989   **CIRCLE NO 194**   269

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CIRCLE NO 195

Booklet lists coaxial components

The vendor's 60-pg catalog provides operating and installation information on switches, detectors, and fixed and step attenuators. The booklet features the company's latest 11-, 70-, and 90-dB step attenuators, which operate to 40 GHz; it also details the 33314 spdt coaxial switch, which has a 5M-cycle life featuring more than 0.03-dB repeatability. Detailed specifications, illustrations, and photos accompany the product descriptions.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. **Circle No. 457**

Guide to surface-mount delay lines

This full-color, 14-pg catalog features a comprehensive range of surface-mount delay lines for military and ruggedized circuit-timing applications. Included are actual-size photos of the various types of products, such as programmable delay lines, pulse-width regulators, passive delay lines, and 5-tap, active delay lines. The booklet also describes the logic families and surface-mount package styles available from the vendor. The guide provides the military specifications met by the delay lines and is organized and color coded for easy referral.

Technitrol, 1952 E Allegheny Ave, Philadelphia, PA 19134. **Circle No. 458**

Brochure describes servo motor technology

Move into the Future with ServoDisc Technology is a 6-pg, full-color leaflet that compares the vendor's disk-armature technology with conventional iron-core servo motors. The pamphlet's illustrations show how the vendor's ironless disk armature achieves cog-free motion. Color charts provide information on the servo motor's accel-

MOVE INTO THE FUTURE WITH *ServoDisc*

Disc armature technology brings new dimensions of performance to dc servo motor applications

eration, cogging, electrical time constant, torque speed curves, and peak torque capability.

PMI Motion Technologies, 49 Mall Dr, Commack, NY 11725. **Circle No. 459**

Note describes custom switch matrixes

A product note, entitled *HP 8760 Custom Switch Matrixes for Microwave ATE*, discusses the manufacturer's capabilities for producing and testing complex switching assemblies. The publication details matrix theory and practice, from 1-channel matrixes to more complex full-access models with numerous inputs and outputs. Other details include performance specifications and how to document test procedures and construction. The note also provides further suggestions for internal self-test procedures.

Hewlett-Packard, 19310 Pruneridge Ave, Cupertino, CA 95014. **Circle No. 460**

How to condition thermocouple signals

The company's application note, *AN-28: Thermocouple Measurements*, opens with a brief history of thermocouples and a table showing the relative precision and accuracy of common thermocouple

types. The main thrust of the note is on electronically conditioning thermocouple signals to improve the accuracy of their temperature measurements. It includes a discussion of cold-junction compensation, signal-amplifier selection, isolation, and linearization. Also included are schematics for electronic cold-junction compensators.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. **Circle No. 461**

Data book of amplifiers

The 224-pg data book, entitled *Microwave and Millimeter Wave Amplifiers*, describes a complete line of military, industrial, commercial, and telecommunications microwave and millimeter-wave-amplifier products. Introduced in this issue are a line of microstrip gain modules, as well as a wide range of high-power amplifiers and millimeter-wave amplifiers operating as high as 60 GHz. Product categories include low-noise, gain-control, and power and limiting amplifiers; millimeter-wave down-converter assemblies; and solid-state traveling-wave-tube amplifier replacements. Also covered are the vendor's transceivers, satellite earth-station amplifiers, and high-power traveling-wave-tube retrofit products for point-to-point

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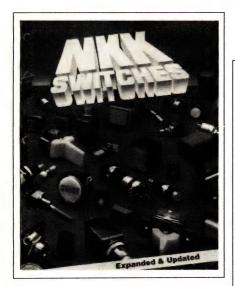
microwave and cellular-radio base-station amplifiers.

Avantek Inc, M/S M82, 481 Cottonwood Dr, Milpitas, CA 95035.

Circle No. 462

Expanded publication of switches

This catalog is a comprehensive compendium of electromechanical switches. The 400-pg book features 36 separate switch families and more than 827,000 different toggle, rocker, pushbutton, slide, keypad, illuminated, rotary, and dip-rotary switches. The dimensional drawings ease the design-in process.

NKK Switches, 14415 N Scottsdale Rd, Scottsdale, AZ 85260. **Circle No. 463**

Catalog covers electronic materials

This 120-pg premiere issue describes products for static control; EMI/RFI shielding; wire and harnessing products; identification systems; thermal interface materials; adhesives, coatings, and encapsulations; solder products and pc-board chemicals; pressure-sensitive tapes; film insulating products; and fabricated parts.

Electrical Insulation Suppliers Inc, 300 N Mannheim Rd, Hillside, IL 60162. **Circle No. 464**

Electronic cataloging of trimmers

The SpecTrim electronic catalog is on an IBM PC-compatible 5¼-in. floppy disk and comes with a 22-pg user's guide. You can pinpoint the optimal trimmer for your application and select from a base of 8600 standard part numbers or from performance parameters. Another feature allows you to cross-reference trimmers of the company's model with those of other manufacturers. The disk also features helpful terms and definitions.

Bourns Inc, 100 Columbia Ave, Riverside, CA 92507.

Circle No. 465

Booklet focuses on VXIbus and its applications

This publication presents an overview of the VXIbus and discusses its scope, purpose, and benefits. The booklet also provides sections that demonstrate uses of the VXI standard for integrating an electronic test system, for automatic-test-equipment improvements, for enhanced pulse measurement and generation, and for RF applications.

Racal-Dana Instruments Inc, 4 Goodyear St, Irvine, CA 92718.

Circle No. 447

Kit features logic-analysis system
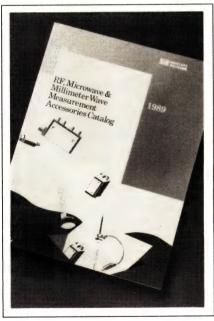
The vendor's packet contains two brochures and four data sheets that describe the CLAS 4000 configurable logic-analysis system. The 4-color brochures deal with "perspectives" and "performance." The Perspectives brochure discusses challenges, configurability, the man/machine interface, the crosspoint switch, and graphics selections. The Performance brochure describes the system, pyramid module sampling and pyramid module trace control, the magnifying-glass module, the system controller, and control specifications. The four data sheets summarize information about the four different models of the probe adapter. Photos, diagrams, tables, and figures illustrate the publications.

Gould Inc, Test and Measurement, 19050 Pruneridge Ave, Cupertino, CA 95014.   **Circle No. 448**

Catalog lists test instruments

The fall 1989 Heathkit Catalog describes several new models: one benchtop and two handheld and digital multimeters; two assembled oscilloscopes; a clamp meter; and an insulation tester. The publication also gives you information on how to purchase a multimeter.

Heath Co, Dept 350-045, Benton Harbor, MI 49022.   **Circle No. 449**

Abundant offering of measurement accessories

RF, Microwave & Millimeter Wave Measurement Accessories Catalog (Literature 5953-2346) presents more than 500 products, including an economy spdt coaxial-switch series; 11-, 70-, and 90-dB step attenuators for 40 GHz; and a family of planar-doped-barrier coaxial detectors. Selection guides and 18 product sections cover fixed and step attenuators; adapters, detectors, power sensors, probes, and 75Ω components; and test accessories and calibration kits for scalar and vector network analyzers. You will also find waveguide and flange data, coaxial-connector information, band designations, and applications-literature listings.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014.   **Circle No. 450**

Booklet features variety of instruments

The vendor's 20-pg instrumentation catalog presents more than 50 products. The publication describes handheld and bench calibrators, more than 20 process instruments, a full line of compact digital panel meters, and linear power supplies. Product specifications, features, applications, and pricing and ordering information for every product, as well as illustrations, are included in the catalog.

Martel Electronics, Box 897, Windham, NH 03087.

Circle No. 451

Manual sums up VMEbus testing

The *CVMEBS1 User Manual* provides the information needed by VME systems designers and integrators to make full use of the CVMEBS1 bus simulator. The publication is divided into six sections, including general information; a hardware-installation guide and operating manual; listings of arbitra-

tion and interrupt problems; and a section called "Hints and Kinks," which provides supplementary information for troubleshooting VME systems.

C&C Technology Inc, Bldg 9, Unit 60, 245 W Roosevelt Rd, West Chicago, IL 60185. **Circle No. 452**

Extensive catalog presents IEEE-488 products

The vendor's 1989 spring/summer catalog offers an extensive product line of IEEE-488 instrument-control, data-acquisition, and data-analysis products. The 300-pg publication is divided into four sections: application software, GPIB interfaces, data acquisition, and the VXIbus. Recent product additions include updated versions of LabView, LabWindows, and Measure application-software systems; an IEEE-488 data buffer; and a se-ries of IEEE-488 interface kits for Sun, Apollo, DEC, and IBM workstations. The catalog also provides tutorial sections.

National Instruments, 12109 Technology Blvd, Austin, TX 78727. **Circle No. 453**

Flyer highlights token-ring analyzer

This 6-pg pamphlet provides an overview of the vendor's Interview 1000 token-ring network analyzer, which provides information on network utilization, configuration, errors, and network management. The publication shows how the analyzer can benefit you if you plan to install a token-ring local-area network.

Atlantic Research Corp, Teleproducts Div, 7401 Boston Blvd, Springfield, VA 22153.
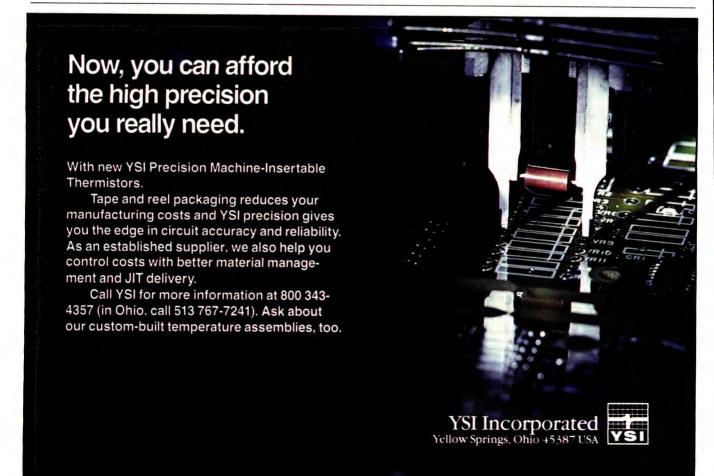
Circle No. 454

Explore and apply source-measure units
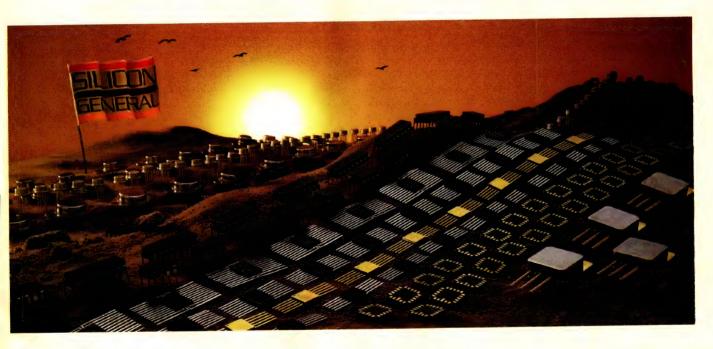
A booklet describes the basic technology of source-measure units and an applications handbook details 24 typical source-measure test configurations. The 24-pg tutorial handbook describes a source-measure unit, how it works, how to design test systems, and how to sample test setups. The handbook also features a glossary and outlines the advantages of source-measure units. The applications overview book deals with 24 common source-measure applications, including MOSFET, GaAs, and bipolar measurements, diode and oxide characterization, and various research and electronic manufacturing test examples.

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139.

Circle No. 455

The smart choice in board testing

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LITERATURE:
COMPUTER-AIDED ENGINEERING

Report discusses effect of logic synthesis

The Impact of Logic Synthesis on Design Automation answers questions such as why logic synthesis is the most popular design technology since design simulation, how logic synthesis differs from silicon compilation, and how much design time logic-synthesis tools can save. The publication forecasts the market for various CAE/CAD tools and projects the impact in dollars that logic synthesizers will have on the 1989-1993 CAE market. It reviews the background of logic synthesizers, as well as currently available products and major companies in today's market. $985.

Electronic Trend Publications, 12930 Saratoga Ave, Suite D1, Saratoga, CA 95070.
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Evaluation of 3-D CAD software

The 250-pg report, *PC CAD Comparison*, provides a comprehensive technical evaluation of the top seven mechanical-engineering software packages. Reviewing Auto-CAD, Micro Cadam, CADkey, Personal Designer, Microstation, Anvil-5000, and VersaCAD, the publication measures how well these seven leading systems perform 800 different functions in eight categories. The study also evaluates the software based on its performance in five benchmarks simulating real-world mechanical-engineering environments. $465.

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Study surveys overseas CASE markets

This major multiclient study on the budding market for computer-aided software engineering (CASE) products in Europe and Japan comprises three volumes. Volume 1 focuses on the European market, where two companies—CGI Informatique of France and Softlab of Germany—are the two leading manufacturers of CASE tools for management-information-system/data-processing applications. Volume 2 concentrates on the European market for CASE tools used in software engineering. In Volume 3, the focus is on the Japanese software market in general and the CASE market in particular. You can buy the volumes separately or as a set. Set $178.50; $59.50 each.

Strategic Focus, 500 E Calaveras Blvd, Suite 321, Milpitas, CA 95035.
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Guide to buying your CAD/CAM tools

The Engineer's CAD/CAM Purchase Checklist can help you make the best decision when you're in the market for a new system. The guide tells you how to double-check your current setup, talk to vendors, check out a component or a peripheral, and look for new applications. In addition to these and other helpful hints, the book offers checklists on training aids; database management; accounting and cost control; hard-copy and communications needs; system and user environment; vendor experience; N/C mill programming; electronic design; pc-board layout; mold analysis programs; and plant design. $29.95 or free with new $154 1-year subscription to *Computer Aided Design Report*.
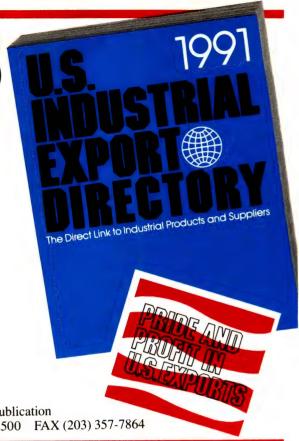
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BOOK REVIEW

Expose budding EEs to test and measurement

Modern Electronic Instrumentation and Measurement Techniques, by Albert D Helfrick and W D Cooper. 446 pgs; $42. Prentice-Hall, Englewood Cliffs, NJ, 1990.

Too many newly graduated electronics engineers (EEs) have little or no appreciation for electronic measurements. After all, the amount of information that electronics-engineering undergraduates must absorb is staggering and is continually increasing. Furthermore, newer areas of electronics—for example, design of µP-based systems, use of computer-aided design to lay out IC chips, and use of graphics software for modeling solid objects—hold much greater interest for fledgling EEs.

Nevertheless, sooner or later in their careers, most EEs discover the importance of an understanding of how to make electronic measurements and a knowledge of the factors that affect the accuracy and repeatability of such measurements. When that time arrives, EEs who haven't had the benefit of formal course work in the test and measurement area must quickly find sources of the information they seek.

Modern Electronic Instrumentation and Measurement Techniques is designed for use as a textbook in an undergraduate course for EEs, but the text will also serve the needs of experienced engineers who must quickly obtain a basic understanding of test and measurement topics to which they were never exposed.

Unfortunately, the book is a rewrite and update of an earlier text, and despite the inclusion of much new material and the removal of some older sections, it hasn't kept pace with the times. For example, the logic analyzer, one of a modern EE's most important tools, isn't treated at all.

Another anachronism is the statement that the power dissipated in the comparators would make a monolithic implementation of an 8-bit flash A/D converter impractical. In fact, such converters have been in commercial production for over a decade. And though the monolithic devices may not be fast enough for use in high-speed, real-time-sampling DSOs, they do provide sampling rates of several MHz. That rate is adequate for the majority of waveform digitizers and also for wideband equivalent-time sampling scopes.

Too much space is devoted to electromechanical-indicating instruments. One could argue that such material is necessary to give the student a historical perspective, but when the use of zener diodes as secondary voltage standards is relegated to a single paragraph, and no information is given on how you compensate a zener to achieve a breakdown-voltage temperature coefficient nominally equal to zero, you have to wonder just how closely in touch with their field the authors have remained.

Yet despite these shortcomings, an experienced EE who has never focused on measurement problems, but who fears that in the not-too-distant future he will be called upon to do so, could do worse than to add this book to his reference collection.—*Dan Strassberg*

WHAT'S COMING IN EDN

EDN Magazine's December 21, 1989, issue is the second installment of our December Product Showcase. It will contain staff-written articles and product reviews in four key technology areas:
- *Instruments*
- *Computers & Peripherals*
- *Computer-Aided Engineering*
- *Components*.

Also, be sure to look for our regular departments.

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Who owns your ideas?

Part 1 of this 2-part article discusses employment agreements and trade secrets.

Jay Fraser, *Associate Editor*

If it's your idea, you have the right to capitalize on it, don't you? Not necessarily.

The answer to this question depends on many factors, including whether or not your idea is derived from a trade secret, and, in particular, whether or not you're bound by an employment agreement.

At some time in your career you'll probably be asked to sign an employment agreement. Make sure you read it carefully before you do. Employment agreements have been argued over since they were first devised. Employers claim that they're necessary to protect trade secrets and to keep proprietary information confidential. Some employees claim that they're unnecessarily restrictive and that their real purpose is to prevent people from starting their own companies. Battles over employment agreements are still being fought in the courts, but some clear parameters have been established. You should be aware of them.

Most employment agreements contain an invention and discovery assignment provision. This provision states that the rights to all inventions and discoveries you make during your term of employment belong solely to the company. Usually, an assignment provision spells out that the company owns all the rights to the inventions or discoveries, regardless of whether they're patentable, made by one person or by a team, or made during working hours.

Assignment provisions aren't as all-encompassing as they might

Jon McIntosh

seem, however. Courts have ruled that your company can claim the rights to your inventions or discoveries only if:

- Your inventions and discoveries relate directly to the company's business or research.
- Your inventions or discoveries were made using the company's facilities or trade secrets.
- Your inventions or discoveries are in some tangible form; assignment provisions can't cover abstract ideas.

You can negotiate an agreement

If you find yourself confronted by an employment agreement, don't assume you have only one choice—to sign it or forgo the job. Employment agreements can be negotiated. For example, if you expect to be paid for your inventions in addition to your regular salary, you should insert a paragraph to that effect into your employment agreement.

If you've made any discoveries or inventions before you go to work for a company, be sure to add a disclaimer and a complete list of them to your employment agreement. If you do end up in court, and you haven't established that you made discoveries and inventions before you were hired, you could lose the rights to them.

Including a disclaimer about your prior discoveries or inventions is important for another reason: It establishes the extent of your knowledge before you join the company. Firms guard their trade secrets jealously, and if any disputes arise, it may be crucial for you to prove that you arrived with a certain knowledge and didn't learn it on the job.

Companies have a legal right to protect their trade secrets, but problems occur because the definition of a trade secret is very broad. A trade secret can be an algorithm, formula, design, pattern, process, sales strategy, customer list, or simply an idea. Almost anything a company possesses that gives it an advantage over its competitors can be called a trade secret.

Another problem with trade secrets is that no federal laws govern them. Each state has its own group of laws, and they vary widely. Nevertheless, some general guidelines do exist.

Companies must protect secrets

A company must make a genuine effort to keep its trade secrets confidential. It can do this by requiring visitors to sign in, limiting the copying of documents, stamping documents "confidential," destroying duplicate copies of documents, and restricting access to areas where proprietary information is stored. A company must also make sure that

Five forms of protection for your ideas

Trade Secret Laws—Anything that gives a company an advantage over its competitors, including an abstract idea, can be termed a trade secret. As long as a firm takes precautions to keep information confidential, it can claim that information is a trade secret. One advantage of a trade secret is that it can provide protection for an unlimited length of time. One disadvantage is that someone else could develop the same information independently and copyright or patent it. Then the originator would lose all rights to it. There are no federal laws governing trade secrets, and state laws differ widely.

Copyrights—Copyrights protect "works of authorship." These include literary, musical, and artistic works, and since 1976, computer programs. A copyright grants an author exclusive rights to reproduce, distribute, and sell his work. Copyrights protect only the expression of an idea, not the idea itself. A copyright lasts for the life of the author plus 50 years.

Patents—Patents provide protection for inventions, processes, and innovative improvements on existing products. Unlike copyrights, patents protect not only the inventions, but also the ideas underlying them. Except when national security is involved, patents provide a description of the invention. A US patent grants a person a monopoly over the manufacture and sale of his invention for 17 years.

Trademarks—Any sign, word, design, letter, number, color, or shape that distinguishes the source of one product from others is a trademark. A company acquires rights to a trademark as soon as it begins to use it. However, if a product is sold or transported in interstate commerce, then it should be registered with the federal Patent and Trademark Office.

The Semiconductor Chip Protection Act—In 1984, Congress passed this law to protect "mask works," the 3-D features in the layers of a semiconductor chip. The act prevents companies from reproducing registered mask works, but not from reverse engineering a chip for purposes of teaching or analysis.

its employees are aware of what information it regards as proprietary. If it doesn't, a court may rule that the information isn't protected by law.

Courts have ruled that the knowledge employees acquire as a normal part of their work experience can't be considered a trade secret. A firm can claim it owns the rights to a device you invent, but it can't claim that it has a right to the knowledge you gained while inventing it.
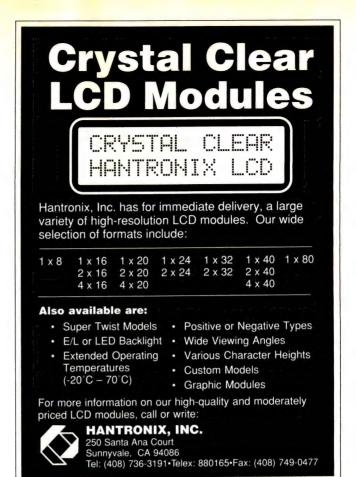
Some companies have tried to protect their trade secrets by adding a noncompetition clause to their employment agreements. These clauses prohibit an employee from going to work for a competing firm for a specified length of time, usually one or two years. Sometimes they also prohibit employees from starting their own firms until one or two years have passed.

Noncompetition clauses have created a great deal of controversy. Four states—California, Michigan, Florida, and Alabama—have made them illegal. Although they're still valid in other states, in legal disputes courts have usually favored the rights of employees.

For a noncompetition clause to be legally binding, a company must prove that the clause is necessary to protect its legitimate interests. Also, the clause must be reasonable in the amount of time it restricts someone from working for a competitor or starting his own firm. The courts have frowned on a limit of more than two years. In general, the courts are reluctant to place too many restrictions on where and how someone can earn a living.

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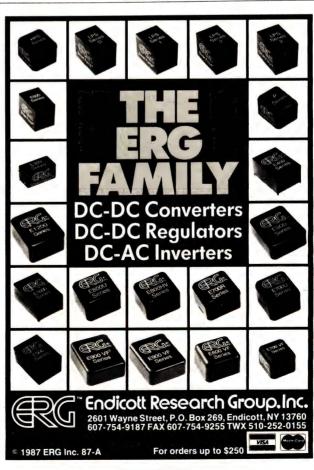
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Issue	Issue Date	Ad Deadline	Editorial Emphasis
Magazine Edition	Jan. 4	Dec. 14 '89	Signal Processing ICs, Computer Systems, Microprocessors, Software, Calendar of Industry Events
News Edition	Jan. 11	Dec. 19	ICs/Programmable Logic, Aerospace/Defense, Regional Profile: Texas
Magazine Edition	Jan. 18	Dec. 28	Analog ICs, Computer Boards/Microprocessors, Software/Programming, Technical Article Database
News Edition	Jan. 25	Jan. 4 '90	CAE/Software, Medical, Special Supplement: Engineering in the 1990s
Magazine Edition	Feb. 1	Jan. 11	Computer Boards/Microprocessors, Analog ICs, Buscon Preview, CAE Software, Power Circuits
News Edition	Feb. 8	Jan. 19	Instruments/Board Level, System Integration, Special Supplement: Embedded Systems/Microprocessors
Magazine Edition	Feb. 15	Jan. 25	Digital ICs, Computer Systems, Interconnect Technology, Sensors
News Edition	Feb. 22	Feb. 2	CAE/Hardware, Telecom, Regional Profile: No. California
Magazine Edition	Mar. 1	Feb. 8	Computer-Aided Engineering/ASICs, Computers & Peripherals, Digital ICs/Microprocessors, Semicustom ICs
News Edition	Mar. 8	Feb. 15	Analog/ICs, Automotive Electronics, Special Supplement: RISC/Microprocessors
Magazine Edition	Mar. 15	Feb. 22	Analog ICs, Components, Engineering Software, Special Design Project #1
News Edition	Mar. 22	Mar. 2	Optoelectronics, Peripherals, Regional Profile: New York, Pennsylvania & Connecticut
Magazine Edition	Mar. 29	Mar. 8	Software Special Issue—Interface ICs, Software/Programming/Microprocessors/ASICs, April Fools Section, Special Design Project #2
News Edition	Apr. 5	Mar. 16	IC/Logic ICs, Distribution, Special Supplement: Distribution
Magazine Edition	Apr. 12	Mar. 22	Communications Special Issue—Communication ICs, Communication Systems, Microprocessors, Special Design Project #3
News Edition	Apr. 19	Mar. 30	ICs/Graphics Controllers/Microprocessors, Industrial Automation, Regional Profile: So. California
Magazine Edition	Apr. 26	Apr. 5	Computer Boards/Microprocessors, Power Sources, Sensors/Transducers, Special Design Project #4, Electro Show Issue
News Edition	May 3	Apr. 12	CAE/Board Layout, Education, Special Supplement: ASICs, Electro Show Issue
Magazine Edition	May 10	Apr. 19	Analog Technology Special Issue—Analog ICs, Analog Instruments, Digital ICs/Microprocessors/ASICs, Special Design Project #5

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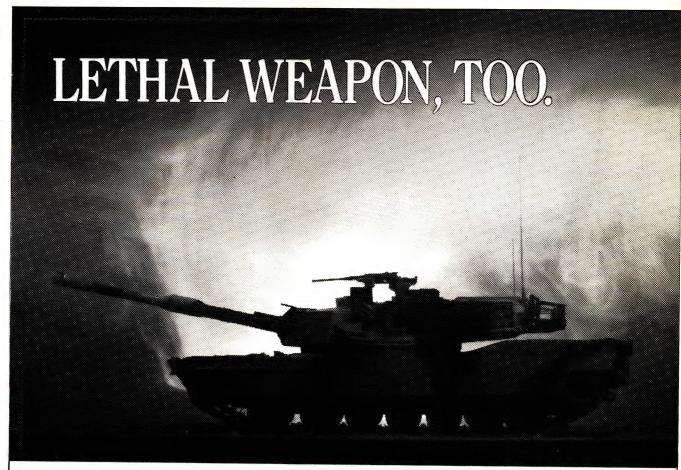
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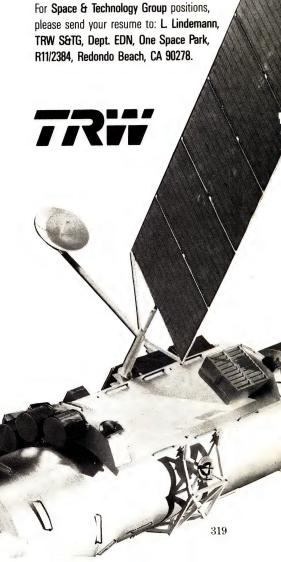
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